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ff 653 July 65

LUNAR SURFACE STUDIES

A CONTINUING BIBLIOGRAPHY
WITH INDEXES

FACILITY FORM 602

N 68-32631
(ACCESSION NUMBER)

115
(PAGES)

30
(CATEGORY)

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LUNAR SURFACE STUDIES

A CONTINUING BIBLIOGRAPHY WITH INDEXES

A Selection of Annotated References to
Unclassified Reports and Journal Articles
introduced into the NASA Information System
during the period February 1967–December
1967.



Scientific and Technical Information Division

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, D.C.

JUNE 1968

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INTRODUCTION

What *Lunar Surface Studies* is

This publication is the fourth supplement to the continuing bibliography, *Lunar Surface Studies*, NASA SP-7003. It contains references to reports and journal articles announced in the NASA abstract journals during the period February through December, 1967. 361 references are included.

Previous bibliographies in this series are NASA SP-7003 (January 1962–March 1964), NASA SP-7003(01) (April 1964–January 1965), NASA SP-7003(02) (February 1965–January 1966), and NASA SP-7003(03) (February 1966–January 1967).

Scope of Bibliography

References are included for lunar surface studies of various factors. Examples of topics covered are theory of lunar origin, the lunar atmosphere, and the physical characteristics of the lunar surface, such as topography, geology, and stratigraphy. Also included are references to techniques of lunar observation, measurement, and analysis, e.g., photography, photometry, and spectrophotometry, as well as to the instrumentation and equipment used in lunar investigations.

Organization of Bibliography

The bibliography is arranged in Abstracts and Index sections. The Abstracts section contains bibliographic citations and informative abstracts for the references selected from *STAR* (*Scientific and Technical Aerospace Reports*), *IAA* (*International Aerospace Abstracts*), and *Aerospace Medicine and Biology* (NASA SP-7011). The *STAR* abstracts are listed first, followed by the *IAA* and the *Aerospace Medicine and Biology* abstracts. Each set of abstracts is arranged in ascending accession number order.

The Index Section contains two indexes, subject and personal author, in that order.

How to Use this Bibliography

Reports are referenced in the *STAR* Abstracts section. Published literature items are referenced in the *IAA* Abstracts and the *Aerospace Medicine and Biology* Abstracts sections. The subject index may be used to locate references to specific topics or technical areas; the personal author index may be used to locate references to reports or articles written by a particular individual.

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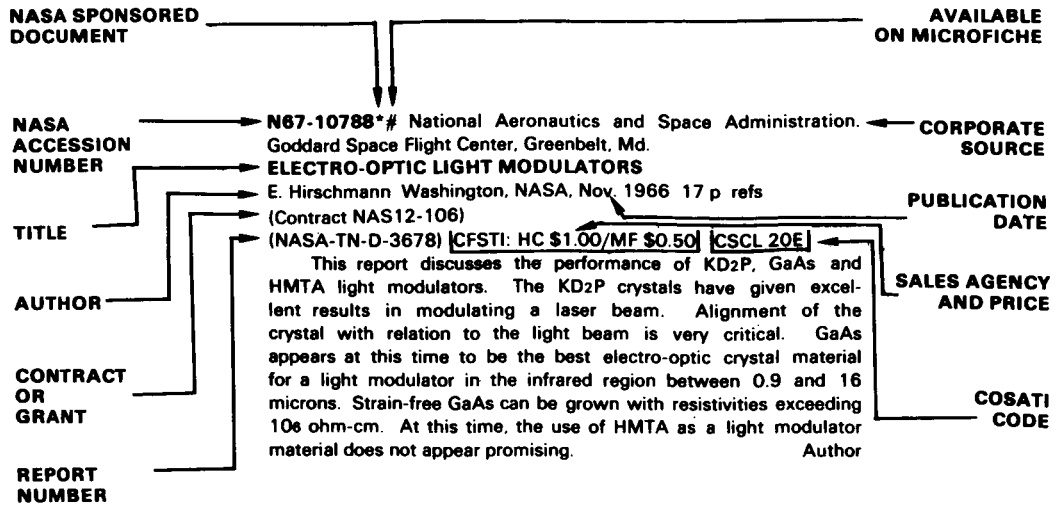
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Aerospace Medicine and Biology References (A67-80000 Series)

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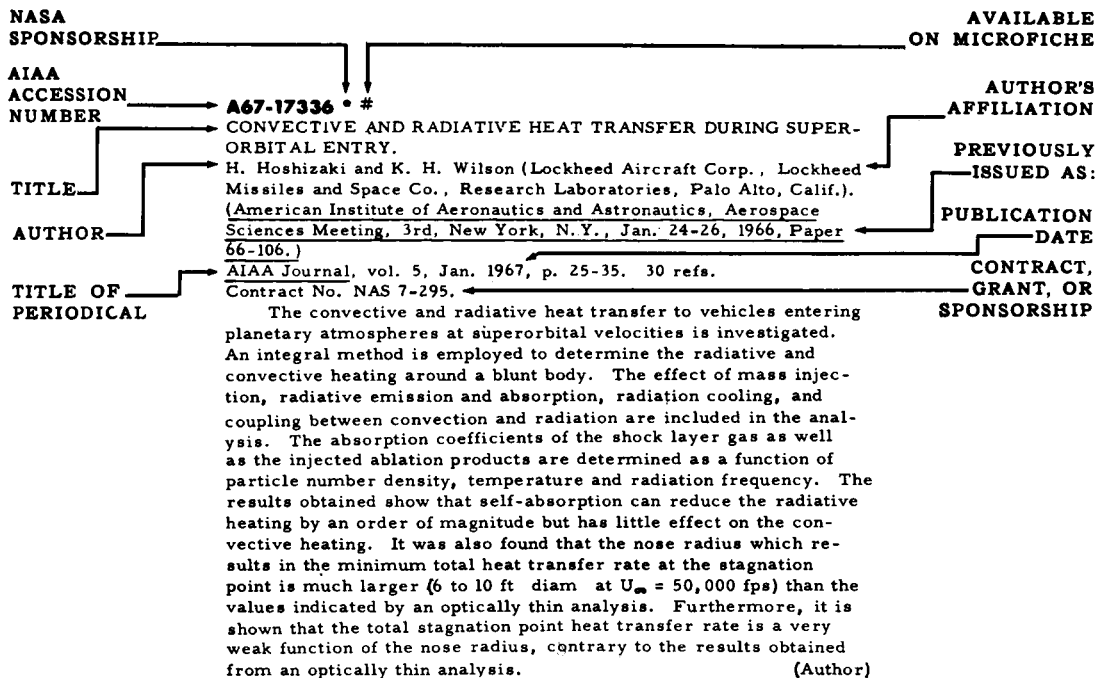
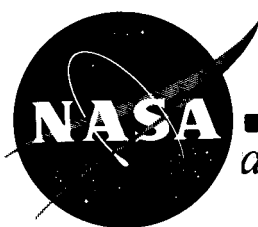


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LUNAR SURFACE STUDIES

a continuing bibliography with indexes JUNE 1968

STAR ABSTRACTS

N67-16956# Air Force Cambridge Research Labs., Bedford, Mass
**RAPID REMOTE AND SENSING BY SPECTRUM MATCHING
TECHNIQUE. PART 2: APPLICATION IN THE
LABORATORY AND IN LUNAR OBSERVATIONS**

Graham R. Hunt, John W. Salisbury, and John W. Reed /n
AEDC Proc. of the 13th Ann. AF Sci. and Eng. Symp., Vol. I
1966 29 p refs CFSTI: HC \$3.00/MF \$0.65

A spectrum matching technique has been developed for rapid remote sensing of mid-infrared molecular vibration emission spectra of lunar and planetary surfaces. It is primarily useful when the remote sensing must be carried out in the presence of a variable intervening attenuator, which puts a premium on rapidity of measurement. A major advantage is achieved over conventional spectroscopic techniques when compositional differences and/or general compositional trends, rather than absolute composition, are the parameters to be measured. Laboratory tests of this technique with a simple spectrum matching instrument and with a more sophisticated x-y scanning instrument have demonstrated its feasibility. Use of the simple instrument on lunar targets has delineated very small, but consistent differences between different areas on the lunar surface. Among other things, these data indicate that the lunar surface materials possess a rough surface on a micron scale.

Author

N67-17166*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
**SURVEYOR I MISSION REPORT. PART III: TELEVISION
DATA**

R. H. Steinbacher, S. Z. Gunter, R. L. Spencer, D. R. Montgomery,
L. D. Jaffe et al 1 Nov. 1966 291 p
(Contract NAS7-100)

(NASA-CR-81520; JPL-TR-32-1023) CFSTI: HC \$3.00/MF \$0.65
CSCL 22A

Some 281 selected television photographs of the lunar surface, as acquired by and sent from Surveyor I between June 2 and July 14, 1966, are presented. Accompanying information provides assistance in the interpretation of these pictures. The supporting material comprises descriptions of the television subsystem, the orientation of camera and sun, the ground photo recording system, and camera parameter information. In addition, 32 preliminary mosaics aid with spatial relationship interpretation.

Author

N67-17777*# Southern Illinois Univ., Carbondale. School of Technology.

STRUCTURAL DESIGN CONCEPTS—TECHNICAL BRIEF

[1966] 9 p

(Grant NSG-607)

(NASA-CR-70408) CFSTI: HC \$3.00/MF \$0.65 CSCL 13M

A concept of element-face rotation-translation transformation of polyhedral forms is presented as a structural design concept. Ideas regarding subsurface supported structural columns for lunar application are advocated through use of a tubular column fabricated from low density ductile material. Insertion into the lunar surface is achieved by an explosive charge enclosed within the tube or by a root-like system filled with a resin-activator mixture which could be forced into the soil. Consideration is also given to a self-generated truncated cone used for planetary structures.

S.P.

N67-18007*# Cornell Univ., Ithaca, N. Y. Center for Radiophysics and Space Research.

**RADAR STUDIES OF THE LUNAR SURFACE EMPHASIZING
FACTORS RELATED TO SELECTION OF LANDING SITES
Status Report, 1 Jul.—31 Dec. 1966**

Jan. 1967 37 p refs

(Grant NGR-33-010-024)

(NASA-CR-81718; CRSR-260) CFSTI: HC \$3.00/MF \$0.65
CSCL 03A

Investigation of the characteristics of the lunar surface are reported, and details are given on the mapping of the lunar surface at 430 Mc/s ($\lambda = 70$ cm) and measurement of the radar cross section of the moon at 40 Mc/s ($\lambda = 7.5$ m). The mapping of radar reflectivity of the lunar surface at 430 Mc/s, with a resolution on the lunar surface of 5 to 10 km, is described. A normalized reflectivity was mapped, so that a change in radar reflectivity could be directly related to a local change in lunar surface. It is hoped that by observing the expected and depolarized components it will be possible to establish whether this change is due to a change in roughness. Technical aspects of the mapping studies are discussed, a time scheduling for the study is included, and future research plans are outlined.

L.E.W.

N67-18043* Volt Technical Corp., Washington, D. C.
LUNA-13 IS ON THE MOON [LUNA-13—NA LUNE]

4 Jan. 1967 18 p Transl. into ENGLISH from RUSSIAN

(Contract NAS5-12487)

(NASA-CR-81705; ST-PR-LPS-10545) CFSTI: HC \$3.00/MF
\$0.65 CSCL 22B

This paper summarizes the various communiques relative to the soft landing on the Moon of the new automatic lunar station (ALS) LUNA-13. The first photographs transmitted are presented herewith in their order of publication. Except for the direct study of the solidity and constitution of the lunar surface layer by driving a rod into its surface on command, and of which

the devices and procedures are described in detail, the performance of LUNA-13 is in every way analogous to that of LUNA-9. It corroborates the earlier findings concerning the absence on the Moon of a dust layer. The data on the structure of the ground lead to the same conclusions of those of LUNA-9 and SURVEYOR-1.

Author

N67-18085*# California Univ., San Diego. Visibility Lab.
VISUAL PERFORMANCE ON THE MOON

John H. Taylor Jan. 1967 13 p refs Presented at the 17th Congr. of the Intern. Astronautical Federation, Madrid, 13 Oct. 1966

(Grant NGR-05-009-059)

(NASA-CR-81756; SIO-Ref.-67-3) CFSTI: HC \$3.00/MF \$0.65 CSCL 05E

This paper discusses the optical and photometric properties of the lunar surface environment and their implications for human visual performance. The need for specialized training of selenonauts is pointed out, and some suggested studies for the Lunar International Laboratory are given.

Author

N67-18490* Volt Technical Corp., Washington, D. C.
CURRENT PROBLEMS OF MORPHOLOGY OF MOON'S SURFACE [TEKUSHCHIYE PROBLEMY MORFOLOGII POVERKHNOSTI LUNY]

Yu. N. Lipskiy, Yu. P. Pakovskiy, A. A. Gurshteyn, V. V. Shevchenko, and M. M. Pospergelis 20 Dec. 1966 17 p refs Transl. into ENGLISH from Kosmich. Issled. (Moscow), v. 4, issue 6, Nov.-Dec. 1966 p 912-922

(Contract NAS5-12487)

(NASA-CR-82093; ST-LPS-10547) CFSTI: \$3.00/MF \$0.65 CSCL 03B

A preliminary analysis is presented of the characteristics of the lunar surface as determined by photographs taken by the automatic interplanetary station Zond III. Data are included on the morphological study of the lunar crust to determine the distribution of continental and mare regions. Specific depressions, hundreds of kilometers in diameter, are reported for the invisible hemisphere of the moon; and these depressions, comparable in area with lunar maria, are described by the term "thalassoid." Two types of annular depressions are noted, and both are referred to as basins. Characteristics of the various types of formations are described, particularly those discovered on the far side of the moon. M.W.R.

N67-18546* Northwestern Univ., Evanston, Ill.
A PATROL OF THE LUNAR SURFACE WITH A 24-INCH REFLECTOR AND IMAGE ORTHICON SYSTEM Semiannual Status Report, 1 Jun.-30 Nov. 1966

J. Allen Hynek 30 Nov. 1966 11 p

(Grant NsG-597)

(NASA-CR-82013) CFSTI: \$3.00 CSCL 03A

The lunar patrol program activities, a comparison with the Moon Blink and Argus Astro-net programs, and the equipment and facilities are described. The meteorological conditions are mentioned, and the red-blue blink patrol, concurrent infrared observations, and visual observations of the earthlit portion after new moon are reviewed. Areas where surface activity was systematically patrolled each night include Aristarchus, Alphonsus, and Copernicus. It was felt that with respect to instrumentation, location, library, and maintenance and repair facilities, the Corralitos observatory offers greater capability than other programs. N.E.N.

N67-18911* Texaco Experiment, Inc., Richmond, Va.
LUNAR GEOPHYSICAL SURFACE AND SUBSURFACE PROBES FOR APOLLO APPLICATIONS PROGRAM. VOLUME I: DETAILED TECHNICAL REPORT

R. H. Clinard, Jr. 27 May 1966 444 p refs

(Contract NAS8-20085)

(NASA-CR-82157; EXP-462, Vol. I; TP-277, Vol. I) CFSTI: \$3.00 CSCL 22B

A study has been carried out to determine the optimum integrated instrument probes to be used for manned lunar exploration with the Apollo Applications Program. A lunar probes system is recommended consisting of: an optimum subsurface probe, a subsurface neutron-gamma probe, a subsurface television probe, and integrated surface probe, a supporting electronics package, a deployment and cable assembly, and an acoustic source holder. This system is described in detail with the justifications, instruments characteristics, and operations requirement of the selected experiments given. Information is also included on experiments considered in the study, which do not appear in the recommended system. Non-functional mockup hardware of the recommended probes was constructed for use in system integration studies and time-and-motion-study testing.

Author

N67-18987*# Bureau of Mines. Minneapolis, Minn. Twin Cities Mining Research Center.

MULTIDISCIPLINARY RESEARCH LEADING TO UTILIZATION OF EXTRATERRESTRIAL RESOURCES Quarterly Status Report, Oct. 1, 1966-Jan. 1, 1967

1 Jan. 1967 41 p refs

(NASA Order R-09-040-001)

(NASA-CR-82469) CFSTI: HC \$3.00/MF \$0.65 CSCL 22A

The Bureau of Mines and NASA are conducting a cooperative program to study the properties and applications of simulated lunar materials. Research is directed toward providing knowledge needed for development of an extraterrestrial mineral resource extraction, processing, and utilization technology for supporting and enhancing the economy of manned lunar and planetary missions. Summaries are presented for over twenty related studies. A.G.O.

N67-19121*# Grumman Aircraft Engineering Corp., Bethpage, N. Y.

MECHANICAL, OPTICAL, THERMAL AND ELECTRICAL PROPERTIES OF THE SURVEYOR 1 LANDING SITE

John D. Halajian Nov. 1966 37 p refs Presented at the Am. Astron. Sci. Meeting, Huntington Beach, Calif., 17 Sep. 1966

(NASA-CR-82458; AS-424-4) CFSTI: HC \$3.00/MF \$0.65 CSCL 03B

Surveyor 1 data are evaluated with particular emphasis on the soil mechanics of the landing site. A downward revision of the bulk density of the lunar surface material from a previously suggested value of 1.5 g/cm³ to about 1 g/cm³ is proposed on the basis of mechanical, thermal, photometric and dielectric evidence. The revision indicates an underdense, partially consolidated material that can be approximated on earth by snow or semi-welded tuffs. The principles of conventional soil mechanics do not readily apply to the study of such materials. Further analysis of Surveyor 1 data and, particularly, coordination between astronomical and on-site measurements of the lunar surface are suggested to refine these estimates and increase the usefulness of future Surveyors.

Author

N67-19215# Defence Research Board, Ottawa (Ontario).
SIZE OF LUNAR CRATERS AND THE CHRONOLOGY OF THE MOON

Hitoshi Takeuchi and Hitoshi Mizutani Nov. 1966 5 p refs Transl. into ENGLISH from Kagaku Kogyo (Japan), v. 36, no. 7, 1966 p 392-393

(T-92-J) CFSTI: HC \$3.00/MF \$0.65

Recent research concerned with determining the relative ages of different lunar terrains using rules modeled on those of terrestrial geology are discussed. Also presented is an argument

that attempts to explain why lunar craters are larger in diameter and depth than meteorite craters on the earth. The argument is based on the fact that the moon's gravitational force is one-sixth of that on the earth's surface. R.N.A.

N67-20274*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

LUNAR SURFACE: AN INTERPRETATION BASED ON PHOTOGRAPHIC DATA FROM THE RUSSIAN LUNA IX AND UNITED STATES SURVEYOR I

Otha H. Vaughan /In its Aero-Astrody. Res. Rev. No. 5 15 Oct. 1966 p 138-144 refs

Lunar surface implications are considered from photographic data provided by Luna IX and Surveyor I. The striking similarity of different lunar area terrain is pointed out, and some of the pitfalls in interpretations of a surface based on photographs alone are discussed. Based on the Lunar IX and Surveyor I data, a realistic model which represents the areas in which these two spacecraft landed is also presented. A.G.O.

N67-20410* Virginia Univ., Charlottesville. Dept. of Astronomy DEVELOPMENT OF TABLES FOR USE IN CELESTIAL NAVIGATION ON THE LUNAR SURFACE Final Report

David D. Meisel, Laurence W. Fredrick, and Peter J. Shells 15 Jan. 1967 136 p refs

(Contract NAS8-20274)

(NASA-CR-83050) CFSTI: HC \$3.00 CSCL 17G

A computer program in the ALCOL programming language was generated which produces ephemeris and almanac data for use in celestial navigation on the lunar surface. The structure and philosophy of the resulting Lunar Astronomical Navigation System (LANS) are outlined. Although its present accuracy is not quite sufficient for surface geodetic studies, it is probably sufficient for all celestial navigation tasks. Difficulties still remain with some of the physical constants but they could be much improved when the lunar orbiter and surveyor programs are completed. Using the LANS basic program and gravity and geoid constants, a set of tables were generated giving deflections of the vertical, the total gravity vector and the normalized geoid radius as a function of spherical longitude and latitude. Also generated was a table of the gravity and geoid pseudo-coordinates as a function of spherical longitude and latitude. R.N.A.

N67-20416*# Air Force Cambridge Research Labs., Bedford, Mass. Lunar-Planetary Research Branch.

REMOTE DETECTION OF LUNAR WATER DEPOSITS

Roger A. Van Tassel and John W. Salisbury /In NASA 2d Ann. Meeting of the Working Group on Extraterrest. Resources [1964] p 45-56 refs CFSTI: HC \$3.00/MF \$0.65

Consideration is given to the first step in establishing a lunar refueling station, the detection of water deposits. Because of the hostile lunar environment and the large surface area to be explored, it appears that economical water detection must be done by scanning the surface remotely from a lunar satellite or even from the earth. Several possible remote sensing techniques to aid in water detection are reviewed. These include radio wave, infrared, visible, ultraviolet, and X-ray techniques. The examination of these different water detection techniques suggests that measurement of infrared emission is the most promising because it is the least ambiguous. Two examples of rock alternation are described which illustrate that infrared emission can detect lunar water deposits either through a change in grain size, or a change in composition, or both. These anomalies, especially when associated with geological features of probable internal origin such as chain craters, can be used as strong indicators of water deposits. R.N.A.

N67-20419*# North American Aviation, Inc., Downey, Calif.

EXTRATERRESTRIAL RESOURCES IN LIFE SUPPORT SYSTEMS

H. M. Conrad and S. P. Johnson /In NASA 2d Ann. Meeting of the Working Group on Extraterrest. Resources [1964] p 75-83 refs CFSTI: HC \$3.00/MF \$0.65

The use of indigenous lunar materials for food, water, livable atmosphere, and waste management subsystems in life support systems is discussed. For reasons of economy, the subsystem requirements are believed to be best satisfied by a semi-closed ecological system. The semi-closed ecological system comprises several integral subsystems including a crew, a water reclamation and purification unit, a waste disposal unit, an algal subsystem, a high plant unit, a small animal colony for meat production, and a physico-chemical environment control system. An integrated extraction device using a solar-nuclear-plasmatron train for extracting useful compounds from lunar rocks is shown and discussed. Hardware items, which can be made by liquifying and molding lunar basalts using a nuclear power heat source, are listed. Current concepts for the modular development of a lunar base are illustrated and discussed along with an example of an early incorporation of biological systems into the life support module, and the algal system incorporated into the partial biological life support system. A chemical analysis of lunar type rock constituents indicates that when properly enriched with nitrogen they can support the growth of green plants. R.N.A.

N67-20777# Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires.

GAMMA-EMISSIONS OF SOME METEORITES AND TERRESTRIAL ROCKS; EVALUATION OF LUNAR SOIL RADIOACTIVITY [EMISSIONS GAMMA DE QUELQUES METEORITES ET ROCHES TERRESTRES EVALUATION DE LA RADIOACTIVITE DU SOL LUNAIRE]

Daniel Nordemann (Ph.D. Thesis—Paris Univ.) 1966 105 p refs In FRENCH

(CEA-R-3017)

The gamma-emissions of some terrestrial rocks and of the meteorites Bogou, Eagle-Station, Granes, and Dosso were studied by quantitative low background gamma spectrometry. These measurements and their interpretation lead to the evaluation of the possible gamma-emissions of several models of lunar soils.

Author (NSA)

N67-21449*# Boeing Co., Seattle, Wash.

LUNAR ORBITER I. PHOTOGRAPHIC MISSION SUMMARY

Washington, NASA, Apr. 1967 85 p

(Contract NAS1-3800)

(NASA-CR-782) CFSTI: HC \$3.00/MF \$0.65 CSCL 22B

Readout and evaluation of a series of 20 photos taken by the first Lunar Orbiter spacecraft of Mare Smythii showed that the moderate resolution photos were satisfactory while the high resolution photos contained smeared images caused by electrical transients tripping the focal-plane shutter prematurely. In addition, photos were taken from the far side of the moon, scientific areas on the front side, as well as Earth pictures seen from the Moon. Film processing was completed and the readout of all photos initiated. G.G.

N67-22172*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

PROBLEMS AND TECHNIQUES OF LUNAR SURFACE MINING

S. A. Fields, H. M. Weathers, R. M. Cox, and R. Q. Shotts (Alabama Univ.) 10 Jan. 1967 50 p refs

(NASA-TM-X-53560) CFSTI: HC \$3.00/MF \$0.65 CSCL 22A

Laboratory experiments and test programs indicate that the physical characteristics of lunar surface materials may differ in several respects from those of terrestrial rocks and soils. The vacuum environment was shown to have a pronounced effect upon porosity, bearing strength, adhesion, and the frictional characteristics of simulated lunar surface materials. Studies were made of several surface mining methods which could be adapted for use on the moon. The requirements for power, manpower, and ore production were considered in rejecting certain systems commonly used on earth. Crew safety, weight and delivery costs, simplicity of operation, and mine operations were other factors which further restricted the remaining systems to the ones presented. These preliminary studies indicate that surface mining may be advantageous if the space program becomes large enough to require extensive lunar exploration or planetary exploration from a lunar base or colony. Author

N67-22511** Arizona Univ., Tucson.

COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY, VOLUME 5, PART 3, NO. 72-78

G. P. Kuiper, ed. 1966 127 p refs

(Contract AF 19(628)-4332) CFSTI: HC \$3.00/MF \$0.65 CSCL 03A

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N67-22512** Arizona Univ., Tucson.

THE INITIAL REDUCTIONS OF MEASURES ON STAR-TRAILED LUNAR PHOTOGRAPHS

D. W. G. Arthur *In its Commun. of the Lunar and Planetary Lab.* 1966 p 7-11 (See N67-22511 11-30) CFSTI: HC \$3.00/MF \$0.65

Full details are given for the initial reductions of measures on star-trailed lunar photographs. These reductions determine refraction-free photographic coordinates of limb profile points and points on the disk. These coordinates are referred to axes with the origin at the center of the bright limb with the y-axis directed along the moon's hour circle. Author

N67-22513** Arizona Univ., Tucson.

A DEVICE FOR DETERMINING THE INSTANTANEOUS FOCAL LENGTHS OF LARGE TELESCOPES

D. W. G. Arthur *In its Commun. of the Lunar and Planetary Lab.* 1966 p 13-16 (See N67-22511 11-30) CFSTI: HC \$3.00/MF \$0.65

An instrument for the rapid determination of focal length is described. This is a plateholder that oscillates the plate in declination so as to obtain sinusoidal star trails. The methods of

reduction of the measures for focal length are described and the precision is estimated as one part in 30,000 for good seeing with long-focus refractors. Author

N67-22514** Arizona Univ., Tucson.

SCALE TRANSFER FOR LUNAR PHOTOGRAPHS

D. W. G. Arthur *In its Commun. of the Lunar and Planetary Lab.* 1966 p 17-18 refs (See N67-22511 11-30) CFSTI: HC \$3.00/MF \$0.65

A method is described for transferring scale from one lunar photograph to another. Selenodetic controls are used, and the effects of systematic and random errors in the positions of the selenodetic points are largely eliminated by choosing a suitable pattern of points. The transfer errors are of the same order as those generally met in selenodetic measures. Author

N67-22515** Arizona Univ., Tucson.

THE VALIDITY OF SELENODETIC POSITIONS

D. W. G. Arthur *In its Commun. of the Lunar and Planetary Lab.* 1966 p 19-30 refs (See N67-22511 11-30) CFSTI: HC \$3.00/MF \$0.65

Evidence is presented that strong systematic errors in the earthward coordinates of selenodetic points are introduced at all stages of selenodetic triangulation, that is, in the fundamental point determination from heliometer measures, in the determinations of the secondary points, and in the tertiary or photographic triangulations. In contrast, the best photographic triangulations show virtually no evidence of system in the coordinates parallel to the plane of the limb. Author

N67-22516** Arizona Univ., Tucson.

A METHOD FOR DETERMINING THE MOON'S CONSTANTS OF ROTATION FROM MEASUREMENTS ON SCALED AND ORIENTED LUNAR PHOTOGRAPHS

D. W. G. Arthur *In its Commun. of the Lunar and Planetary Lab.* 1966 p 31-36 refs (See N67-22511 11-30) CFSTI: HC \$3.00/MF \$0.65

A method is described for determining the moon's constants of rotation and the selenodetic coordinates of a number of primary points starting from rectangular coordinate measures on scaled and oriented lunar photographs. The new features are the use of Mösting A as the origin of selenodetic coordinates and the employment of rigorous formulas in place of the approximate differential formulas of classical selenodesy. The least squares analysis takes into account the algebraic correlation introduced in the reductions of the observed points. Author

N67-22517** Arizona Univ., Tucson.

SELENODETIC MEASURES ON YERKES LUNAR PHOTOGRAPH NO. 1269

D. W. G. Arthur *In its Commun. of the Lunar and Planetary Lab.* 1966 p 37-38 ref (See N67-22511 11-30) CFSTI: HC \$3.00/MF \$0.65

Details are given of the measures and reductions for 1868 points on Yerkes lunar photograph No. 1269. The catalog lists the uncorrected photographic coordinates, the refraction-free photographic coordinates, and the standard direction-cosines of 1464 points on the disk. Also given are the uncorrected coordinates and the refraction-free photographic rectangular and polar coordinates of 404 points on the bright limb. Author

N67-22518** Arizona Univ., Tucson.

SELENODETIC MEASURES ON YERKES LUNAR PHOTOGRAPH NO. 482

D. W. G. Arthur *In its Commun. of the Lunar and Planetary Lab.* 1966 p 41-43 refs (See N67-22511 11-30) CFSTI: HC \$3.00/MF \$0.65

Details are given of the measures and reductions for 1438 points on Yerkes lunar photograph No. 482. The catalog lists the uncorrected photographic coordinates, the refraction-free coordinates, and the standard direction-cosines of 990 points on the disk. Also given are the uncorrected coordinates and the refraction-free photographic rectangular and polar coordinates of 448 points on the bright limb. The disk and limb surveys are incomplete because of plate damage. Author

N67-22731# Boeing Scientific Research Labs., Seattle, Wash. Geo-Astrophysics Lab.

REVIEW OF LUNAR INFRARED OBSERVATIONS

J. M. Saari and R. W. Shorthill Dec. 1966 51 p refs Presented at the Symp. on the Physics of the Moon, Washington, D. C., 29 Dec. 1966

(D1-82-0586; AD-645548) CFSTI: HC \$3.00/MF \$0.65

Prior to 1960 the lunar surface was known to be highly insulating from the low temperatures observed during an eclipse and the lunar night. Directional effects in the infrared emission from the illuminated surface were understood to result from roughness. In 1960, a number of ray craters were shown to cool more slowly than their environs during an eclipse. Subsequently, this behavior was observed during the lunar night for both ray craters and certain other features. In 1964, the entire disk was scanned during a total eclipse, revealing the presence of hundreds of hot spots. These anomalies have been identified with a variety of geological features. The current status of the thermophysical and geological interpretations of this discovery is discussed. Author (TAB)

N67-23259# Volt Technical Corp., Washington, D. C. **SUCCESS OF LUNA-13. THE MOON IS NOT A DEAD HEAVENLY BODY [SUCCES DE LUNA-13. LA LUNE N'EST PAS UN ASTRE MORT]**

Germain Ajoux 13 Feb. 1967 4 p Transl. into ENGLISH from Pourquoi Pas (Brussels), 12 Jan. 1967 (Contract NAS5-12487)

(NASA-CR-83533; ST-PR-LPS-10562) CFSTI: HC \$3.00/MF \$0.65 CSCL 22A

In performing a study of the lunar soil by radioactivity with Luna-13, Soviet scientists have realized an experiment henceforth classical on Earth, but which constitutes a prominent first in the cosmos. It is generally considered that the data collected by this method will improve considerably the knowledge we now have of the lunar crust. Author

N67-23412# Douglas Aircraft Co., Inc., Huntington Beach, Calif. Advanced Research Lab.

LUNAR EXPLORATION AND SURVIVAL

Jack Green Jun. 1966 141 p refs *Its DARL Res. Communication No. 8*

(Douglas Paper-4038)

The major theories of lunar surface origin are examined in the light of recent probe data as related to exploration and survival problems in the post-Apollo period. Evidence from Ranger, Luna, and Mariner probes is analyzed in an attempt to answer the question of whether the lunar surface features are the result of volcanic processes or meteoritic impacts. The analysis is related to the practical question of lunar survival because the exploration and survival advantages of a volcanic terrain are superior to those of an impacted one. Consideration is given to initial landing problems, lunar water resources, other potential lunar resources, altitude studies, and location of a lunar base. A.G.O.

N67-23819# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EXPERIMENTAL STUDY OF THE APPLICATION OF PENETROMETER TECHNIQUE TO THE LUNAR SURVEYING STAFF CONCEPT

Huey D. Carden Washington, NASA, May 1967 38 p refs (NASA-TN-D-3937) CFSTI: HC \$3.00/MF \$0.65 CSCL 14B

Mockups of the lunar staff were constructed, and impact tests were conducted on target materials having a wide range of hardness or penetrability to evaluate conceptual and alternative penetrometer designs. Acceleration time histories generated during the impact of penetrometers integral with the staff revealed distinguishing characteristics on penetrable target materials including sands and balsa; however, on firm targets such as lead and concrete, the impact acceleration signatures were distorted by superimposed high-frequency structural responses of the staff. An alternate configuration in which the penetrometer was link-mounted to the side of the staff appeared to eliminate the deficiencies of the integral design. Characteristics of the impact acceleration time histories are shown to provide convenient means for distinguishing between the bearing strength of granular target materials. An increase in target bearing strength is accompanied by an increase in the impact peak acceleration and a decrease in both the total duration of the acceleration pulse and the staff penetration depth. Author

N67-23966* Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div.

EXPERIMENTAL INVESTIGATION OF ULTRAHIGH VACUUM ADHESION AS RELATED TO THE LUNAR SURFACE Quarterly Progress Report, 1 Jan.-31 Mar. 1967

J. A. Ryan 26 Jun. 1964 67 p refs

(Contract NAS7-307)

(NASA-CR-83647; A-830-BBK3-37; QPR-11) CFSTI: \$3.00 CSCL 11B

CONTENTS:

1. EXPERIMENTAL INVESTIGATION OF ULTRAHIGH VACUUM ADHESION AS RELATED TO THE LUNAR SURFACE J. A. Ryan 10 p (See N67-23967 12-18)

2. PRODUCTION OF SURFACE ELECTROSTATIC CHARGING ON DIELECTRICS CLEAVED IN VACUUM: THEORETICAL J. J. Grossman 39 p refs (See N67-23968 12-18)

3. ADHESIONAL BEHAVIOR OF AIR AND ULTRAHIGH VACUUM FORMED SILICATE SURFACES J. A. Ryan and M. B. Baker 23 p refs (See N67-23969 12-18)

N67-23969* Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div.

ADHESIONAL VACUUM FORMED SILICATE SURFACES

J. A. Ryan and M. B. Baker *In its Experimental Investigation of Ultrahigh Vacuum Adhesion as Related to the Lunar Surface* 26 Jun. 1964 23 p refs Presented at the Adhesion of Mater. in Aerospace Environments Symp., Toronto, 1-2 May 1967 (See N67-23966 12-18)

The possible adhesional behavior of lunar silicates was investigated by determining the forces between air-formed (or contaminated) and vacuum formed (clean) surfaces. For the air-formed surfaces, the adhesion force was generally relatively low, in no case exceeding 5×10^2 dynes. Under low load the adhesion appeared to be due to the action of the dispersion forces, and was generally in the range 10^{-1} —1 dyne. At higher loads the adhesion force increased rapidly and appeared to be due to the action of the normal atomic bonding forces. For the vacuum-formed surfaces, it was found that the adhesion force was much larger, and that a considerable amount of surface electrostatic charging was produced during surface formation. The results indicate that the range of lunar adhesional phenomena can be quite large. L.S.

N67-24269*# General Electric Co., Daytona Beach, Fla.
SOME PROBLEMS IN DESIGNING A LUNAR PHOTOGRAPHIC SURVEY MISSION

W. L. Austin and J. L. Harden *In* NASA. Marshall Space Flight Center Proc. of the Interdisciplinary Symp. on Apollo Appl. Programs, 12-13 Jan. 1966 Dec. 1966 p 5-20

Problems associated with the design of a lunar photographic survey mission, specifically the translunar trajectory and preferred lighting ring, are discussed. The preferred lighting ring is discussed in general terms in order to show its characteristics over a 28-day lunar orbit. A 28-day orbit duration is desirable, since regardless of the polar-orbit altitude, the entire surface would rotate under the spacecraft in 27.32 days. The trajectories are discussed for a particular day in a particular synodic month, and are not to be considered as general results. It is a general result, however, that once an arrival longitude and sun angle are specified, there is at best one launch window in any given synodic month. In order to open up this launch window, it would be necessary to vary the boundary conditions at lunar orbit insertion. Author

N67-24270# Hayes International Corp., Birmingham, Ala.
LUNAR TERRAIN ANALYSIS

R. L. Sanders and W. M. Greene *In* NASA. Marshall Space Flight Center Proc. of the Interdisciplinary Symp. on Apollo Appl. Programs, 12-13 Jan. 1966 Dec. 1966 p 21-38

The distribution of lunar topographic and geologic features of scientific interest was analyzed in order to assess surface mobility requirements for early lunar exploration missions. The study provided an analysis of lunar geology and geologic age classification. Classified, reviewed and analyzed, were Aeronautical Chart and Information Center (ACIC-LAC) charts and United States Geological Survey (USGS) maps. A presentation of singular lunar sites of special interest was made, and a study of the Apollo Landing Belt was effected. Author

N67-24271*# Brown Engineering Co., Inc., Huntsville, Ala.
A DISCUSSION OF PROPOSED LANDING SITES FOR AAP LUNAR MISSIONS

John R. Rogers *In* NASA. Marshall Space Flight Center Proc. of the Interdisciplinary Symp. on Apollo Appl. Programs, 12-13 Jan. 1966 Dec. 1966 p 39-60 refs

The following five sites on the lunar surface have been recommended for AAP missions: Hyginus Crater and Rill, Floor of the Crater Alphonsus, Hadley's Rill Region, Censorinus C, and Moltke B. Presented is a discussion of the scientific reasons for selecting each site and information on the nature of geological problems which might be investigated. A possible traverse around Site 2 (Floor of Alphonsus) is outlined. Recommendations for the planning of surface missions are made, based on new detailed information available from Ranger photographs. Author

N67-24272*# Chrysler Corp., New Orleans, La.
DEVELOPMENT OF A LUNAR PHOTOMETRIC FUNCTION FROM EXPERIMENTAL DATA

E. F. Snyder *In* NASA. Marshall Space Flight Center Proc. of the Interdisciplinary Symp. on Apollo Appl. Programs, 12-13 Jan. 1966 Dec. 1966 p 61-116 refs

The need exists for an accurate photometric model of the lunar surface's directional reflection characteristic under all angles of solar illumination. Using an empirical approach and some mathematical theory, a functional expression is developed to describe the existing lunar directional reflectance characteristics. A two-dimensional equatorial photometric function is developed initially, and is expanded into a three-dimensional photometric function.

For ten widely distributed lunar craters, and for the entire range of phase angles, very good agreement is demonstrated between the experimental results and the predicted results using the developed lunar photometric function. The developed three-dimensional lunar photometric function has been integrated over the face of the moon for many phase angles. The integrated brightness at phase angle using the developed photometric function is in excellent agreement with experimental results of Rougier and other investigators. Author

N67-24277*# National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

SOME CONCEPTS FOR AN EMPLACED SCIENTIFIC STATION ON THE LUNAR SURFACE

Russell D. Shelton *In* its Proc. of the Interdisciplinary Symp. on Apollo Appl. Programs, 12-13 Jan. 1966 Dec. 1966 p 215-227, refs

Reported are results of a joint study effort to develop a concept for an emplaced scientific station (ESS) for: (1) acquiring data on the lunar interior by means of seismic detectors and probe measurements; (2) monitoring the lunar atmosphere; (3) measuring fluxes of nuclear and meteoroid particles; and (4) studying the moon as a possible base for improved planetary and stellar astronomy. Physical requirements (storage and packaging), design criteria, and power sources for the ESS are discussed; and instrumentation requirements for lunar surface radiation experiments, studies of lunar body motions, and astronomical studies are reviewed. S.C.W.

N67-24628*# National Research Corp., Cambridge, Mass. Norton Exploratory Research Div.

PROPERTIES OF POWDER GROUND IN ULTRAHIGH VACUUM Final Technical Report, 24 Aug. 1965-23 Aug. 1966

P. Blum, J. R. Roehrig, and M. J. Hordon Mar. 1967 48 p refs

(Contract NAS1-5347)

(NASA-CR-66276) CFSTI: HC\$3.00/MF\$0.65 CSCL 13H

A preliminary investigation was conducted into the properties of lunar soil by simulating the comminution of the rock in ultrahigh vacuum (UHV). Previous simulation studies are reviewed, and the need for vacuum comminution is discussed. Apparatus was constructed for pulverizing the igneous rock in ultrahigh vacuum to permit determination of the properties of powders produced with atomically clean particle surfaces. Both grinding components were made of basalt. Basalt powder was produced while maintaining pressures in the low 10^{-9} and 10^{-8} Torr ranges; this required extensive rock baking prior to comminution, causing a 0.66% weight loss. Comparative data are presented on the properties and behavior of basalt powder ground in vacuum and in air. It was concluded that simulation of lunar soil surface cleanliness by UHV in igneous rock comminution is feasible. M.G.J.

N67-25624# Illinois Univ., Urbana. Electrical Engineering Research Lab.

IONOSPHERIC RESEARCH Quarterly Progress Report, 1 Jul.-30 Sep. 1966

H. D. Webb 30 Sep. 1966 27 p

(Contract DA-36-039-AMC-03703(E))

(QPR-12: AD-647423) CFSTI: HC\$3.00/MF\$0.65

Moon-reflected signals were received on 34 days for approximately 301 hours at 150.6 mc and on 33 days for approximately 61 hours at 413.25 mc. There was solar activity on several observation days, but the data have not been correlated with any natural phenomena. Gains of a right-hand circularly polarized antenna, left-hand circularly polarized antenna, and a dipole in a corner reflector are given as 11.7 db, 8.7 db, and 8.9 db, respectively. Moon reflected signals using the dipole in a corner

reflector antenna were good, with a maximum signal to null ratio of 8 db, indicating that a relatively simple receiving station can be used to receive moon reflected signals. Most of the data have been processed through August 1966. The data for 1965 are being prepared for Volume IV of the Atlas of Lunar Data. Volumes I, II and III of the Atlas have been completed. The station can now be operated automatically in the sense that the antenna can follow the moon automatically and keep the 150.6 mc signal tuned in automatically. Silicon controlled rectifiers are used to replace three magnetic amplifiers in the azimuth control circuits. A clock controlled set of switches are used to turn the equipment on and off at the proper times. The topside to bottomside ionospheric electron content ratio is being studied for the October 1965 data.

TAB

N67-25668*# Litton Systems, Inc., Minneapolis, Minn. Applied Science Div.

INVESTIGATION OF SPUTTERING EFFECTS ON THE MOON'S SURFACE Quarterly Status Report, 25 Apr.-2 Sep. 1966

G. K. Wehner, C. E. Knight, and D. L. Rosenberg 14 Oct. 1966 37 p refs

(Contract NASw-751)

(NASA-CR-83822; Rept.-3037; QSR-13) CFSTI: HC \$3.00/MF \$0.65 CSCL 03B

Experiments to build up thick crusts of powder bombarded by ions throughout its bulk are reported. Cementation of copper powder under dc mercury ion bombardment in a low pressure plasma was demonstrated. But RF bombardment was accompanied by difficulties due to spontaneous formation in the ion sheath of long conducting chains of powder particles. Slow cementation of Al_2O_3 powder occurs under mercury ion bombardment. An experiment designed to detect small fluxes of H_2O emitted from silicates bombarded by ions from a hydrogen discharge plasma revealed significant mass transport of carbon within the discharge region due to chemical attack of carbon on the vacuum tube walls. The analogous process occurring at the lunar surface is examined quantitatively in the light of a recent suggestion that photospheric abundances of the elements may probably be expected in the solar wind flux. It is concluded that significant carbon concentrations may accumulate in a 10^{-5} cm layer of silicate particles exposed on the lunar surface for total times of the order of 10^4 yr.

Author

N67-25746* Earth Science Research Corp., Santa Monica, Calif.
STUDY OF SHAPE AND INTERNAL STRUCTURE OF MOON, UTILIZING LUNAR ORBITER DATA Quarterly Progress Report

Donald L. Lamar Apr. 1967 8 p refs

(Contract NSR-05-264-002)

(NASA-CR-83835; QPR-3) CSCL 03B

It was found that the J_{30} term determined from study of the orbit of Luna 10 has the same sign as the value which would have been predicted from the relationship between the continent-maria distribution and orientation of the principal moments of inertia. Equations have been derived which relate the zonal harmonics of the gravity field to similar terms in a lunar continentality function and the parameters of plausible models of internal structure. A computer program has been written and tested which determines the higher order terms in a continentality function for the moon. A review of previous studies of the shape of the moon is continuing.

Author

N67-25821*# California Univ., Berkeley. Space Sciences Lab.
ANALYTICAL TECHNIQUES FOR IDENTIFICATION AND STUDY OF ORGANIC MATTER IN RETURNED LUNAR SAMPLES Semiannual Report, 1 Oct. 1966-31 Mar. 1967

A. L. Burlingame 31 Mar. 1967 6 p ref /Its Space Sci. Lab. Series No. 8, Issue No. 31

(Grant NGR-05-003-134)

(NASA-CR-83871) CFSTI: HC \$3.00/MF \$0.65 CSCL 07C

Work on an analytical facility for the study of organic lunar matter progressed with the completion of the first stage in computerized high resolution mass spectral data acquisition, processing, and interpretation necessary for the closed-loop computer control of a high resolution mass spectrometry and capillary gas-liquid chromatographic facility. Initial necessary design criteria for the fabrication and testing of a computerized low resolution mass spectrometer were obtained, forwarded to the contractor, and implemented in the upgrading an existing high resolution mass spectrometer. Raw data acquisition software has been written to accept data for direct digitization of the ion multiplier and on-line data acquisition over the interim computer.

G.G.

N67-25828*# Volt Technical Corp., Washington, D.C.

LUNA-12 TRANSMITS PHOTOGRAPHS [LUNA-12 PEREDAYET SNIMKI]

3 Nov. 1966 6 p Transl. into ENGLISH from Pravda no. 303 (17620) (Moscow), 30 Oct. 1966

(Contract NAS5-12487)

(NASA-CR-83863; ST-PR-LPS-10534) CFSTI: HC \$3.00/MF \$0.65 CSCL 22B

Submitted are the photographs obtained from Luna-12 during its flight along a selenocentrical moon orbit. The area photographed contains a small number of craters outlined by illuminated inner slopes. A great number of clear spots constitute agglomerations of tiny craterlets that usually have no walls.

G.G.

N67-25875* Radio Corp. of America, Lancaster, Pa.

DEVELOPMENT OF A STERILIZABLE RUGGEDIZED VIDICON FOR LUNAR AND PLANETARY PHOTOGRAPHY Interim Technical Report, 21 May 1965-21 Aug. 1966

S. A. Ochs Sep. 1966 58 p Prepared for JPL

(Contract NAS7-100)

(NASA-CR-83885) CFSTI: HC \$3.00/MF \$0.65 CSCL 09A

A one inch vidicon was developed which can withstand ethylene-oxide and dry-heat sterilization as well as exposure to severe shock and vibration. The tube has a ceramic-metal modular construction and is potted in a magnetic shield. Electrostatic focusing and deflection are employed. Tubes successfully passed through the sterilization treatment and environmental testing. Electrical performance is encouraging with resolution of over 500 TV lines having been observed.

Author

N67-25892* Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div.

EXPERIMENTAL INVESTIGATION OF ULTRAHIGH VACUUM ADHESION AS RELATED TO THE LUNAR SURFACE Quarterly Progress Report, 1 Jan.-31 Mar. 1967

J. A. Ryan 26 Jun. 1964 68 p refs

(Contract NAS7-307)

(NASA-CR-83926; A830-BBK3-37; QPR-11) CSCL 03B

During this period the system modifications and repairs were completed, the adhesion was measured between differing silicate minerals whose contact faces were formed simultaneously by cleavage at ultrahigh vacuum, and the theoretical analyses of the observed long range attractive forces were continued. The modifications consisted of the design and air testing of a double cleavage device and electrometer probe, and the installation of additional ports and feedthrus and a residual gas analyzer. Repairs involved removing leaks. Of the eight double cleavage runs made, one was successful, one provided some useful information, and six failed. The successful double cleavage run was for orthoclase

(001) and microcline (001). The adhesion force between these was 0.4 gm and gradually dropped below detection in a few hours. A long range attractive force was present, but this had no tendency to rotate or displace the samples. The unsuccessful run which provided some information was also for orthoclase and microcline. Both these samples broke into several pieces, but a small upper microcline segment remained in place and several lower fragments attached themselves to it indicating a long range attractive force.

Author

N67-25963* Hughes Tool Co., Houston, Tex. Research Dept.
**DEVELOPMENT AND PARAMETRIC STUDY OF SMALL
 ROTARY PERCUSSION DRILL FOR EXTRATERRESTRIAL
 DRILLING** Final Report, Dec. 1965-Mar. 1967

R. C. Froebel Mar. 1967 91 p Prepared for JPL
 (Contracts NAS7-100; JPL-951398)

(NASA-CR-83849) CFSTI: \$3.00 CSCL 131

A test program and parametric study to develop a bit and to find drilling parameters which will yield specified particle sizes is described. The program included modifying an existing drilling rig to fit the job requirements, two parametric studies, and bit design and development. As parameters could not be found to yield specified particle size ranges, bit design changes were tried. Observed was a strong correlation between particle size and drilling rate which might be used to advantage. The final analysis of data revealed that drilling parameters and bit design can be optimized to approach the specified particle size ranges but a screening or sizing process will have to be used to meet strict limits in particulate size.

Author

N67-26062*# Houston Univ., Tex.
IN SITU ORGANIC ANALYSIS OF THE LUNAR SURFACE

John Oro [1967] 24 p

(Grant NGR-44-005-043)

(NASA-CR-83968; SAPR-1) CFSTI: HC \$3.00/MF \$0.65 CSCL 07C

After evaluating several instruments, a quadrupole and a monopole mass analyzer have been selected as basic components of an integrated gas chromatographic-mass spectrometric system for the analysis of organic compounds. This system has been assembled and tested in the laboratory. The results obtained with the apparatus are comparable to those obtained with much heavier instruments. Further experimental work will be necessary in order to determine the potential application of a similar (compact and automated) instrument for the analysis of organic compounds on the moon and planetary surfaces.

Author

N67-26132 Defence Research Board, Ottawa (Ontario).
**SIZE OF LUNAR CRATERS AND THE CHRONOLOGY OF
 THE MOON**

Hitoshi Takeuchi and Hitoshi Mizutani Nov. 1966 4 p refs
 Transl. into ENGLISH from Kagaku Kogyo (Tokyo), v. 36, no. 7,
 1966 p 392-393

CFSTI: HC \$3.00

A theory of the chronology of lunar land areas and craters is proposed based on the fact that lunar gravitational force is one-sixth that of the earth's. The parabolic paths of bodies ejected by explosions and below-surface explosions are considered. It is pointed out that the diameters and depths of lunar craters will be approximately six times the diameters and depths of terrestrial craters. It is suggested that if the land areas are 4500 million years old, then the age of the lunar maria is about 230 million years.

N.E.N.

N67-26268*# California Univ., Berkeley. Space Sciences Lab.

RADIATION ANOMALIES ON THE LUNAR SURFACE

David Buhl (Ph.D. Thesis) 20 Jan. 1967 173 p refs /ts Ser.
 No. 8, Issue No. 1

(Grants NsG-101; NsG-243-62)

(NASA-CR-84017) CFSTI: HC \$3.00/MF \$0.65 CSCL 03B

A model of the Moon, which consists of a large number of centimeter and millimeter size craters distributed over the surface, is proposed to account for several of the anomalous results of infrared observations. These observations have shown that the temperature of the subsolar point depends on the angle of observation. In addition, thermal hot spots appear during a lunar eclipse. Such anomalous observations are interpreted as indicating the presence of small craters. In calculating the effect of small scale cratering on observations of the illuminated and eclipsed Moon, a number of physical processes are considered. A detailed calculation of the effect of radiation interchange within the crater is made. Curves are plotted of the infrared brightness of the illuminated crater as a function of the angle of the observer, taking into account the effects of reradiation, local incidence and emission angles, and shadowing. A calculation is also made of the cooling curves for a crater both during an eclipse and during the lunar night. From this it is suggested that centimeter scale craters may be responsible for the observed thermal anomalies.

Author

N67-26382# Smithsonian Astrophysical Observatory, Cambridge, Mass.

**MEASUREMENTS OF GAMMA RADIATION FROM THE
 LUNAR SURFACE AT THE COSMIC STATION LUNA 10**

A. P. Vinogradov, Yu. A. Surkov, G. M. Chernov, F. F. Kirnozov, and G. B. Nazarkina [1966] 20 p refs Transl. into ENGLISH from Russian /ts Astron. Papers Translated from the Russian No. 10

The intensity and spectral composition of the lunar-rock gamma radiation have been investigated with the aid of a gamma spectrometer mounted on the automatic station Luna 10. The preliminary results of the obtained information processing are given in the article. The investigation results evidence that about 90% of the total intensity of lunar-rock gamma radiation is caused by nuclear reactions produced by cosmic rays and only 10% or less belongs to the radiation arising from the decay of the radioactive elements uranium, thorium, and potassium contained in lunar rocks. The general level of gamma-radiation intensity over the lunar surface is 1.5 to 2.0 times higher than over terrestrial rocks of the granite type. According to their content of radioactive elements, lunar rocks correspond to terrestrial rocks of basic composition (basalts).

Author

N67-26415* Consultants and Designers, Inc., Arlington, Va.

**ON THE RELATIVE DEPTH OF LUNAR ANNULAR
 MOUNTAINS AND CRATERS IN THE "MARE NUBIUM" [OB
 OTNOSITEL'NYKH GLUBINAKH LUNNYKH KOLTSEVYKH
 GORI KRATEROV V "MORE OBLAKOV"]**

A. V. Markov 24 Mar. 1966 4 p refs Transl. into ENGLISH from Dokl. Akad. Nauk SSSR, Astronomiya (Moscow), v. 167, no. 1, 1 Mar. 1966 p 63-64

(Contract NAS5-9299)

(NASA-CR-84091; ST-LPS-10463) CSCL 03B

By comparing the photographic data of Ranger VII, the author establishes the fact that the Baldwin formula for the diameter to depth of lunar craters and annular mountains, with D ranging from 200 to 2.0 km, represents sufficiently closely the ratio for D ranging from 8 meters to 67 km. Deflections from formula (1) are observed only in large cirques or in craters having been flooded, at a much later stage, by effusion of lava from within.

Author

N67-26442* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
**THE SCIENTIFIC UTILITY OF UNMANNED LUNAR
 SURFACE ANALYSIS PROBES**

Mar. 1967 19 p refs

(Contract NAS7-100)

(NASA-CR-84125) CFSTI: HC \$3.00/MF \$0.65 CSCL 22B

The philosophy and reasons for inclusion of unmanned surface-contacting probes in the scientific exploration of the moon are summarized. The need for lunar geological information for characterization of major surface lithologic units and as a fundamental requirement for the construction of geologic maps is pointed out. The measurements necessary for lithologic characterization by surface analysis probes are listed, and 17 possible mission targets for unmanned surface probes in the lunar equatorial region are given. A terrain map is included which shows a portion of the lunar equatorial region. The map designates major physiographic units based on their telescopic appearance; these units are listed and briefly characterized in the map's legend. Also briefly discussed is the role of surface probes for investigating areas inaccessible to manned surface parties and for emplacing seismic instruments.

K.W

N67-26511*# Bellcomm, Inc., Washington, D. C.

CRATER STATISTICS AND EROSION

R. J. Collins and B. G. Smith 3 Mar. 1967 25 p refs Presented at the AAS Symp. on the Phys. of the Moon, Washington, D. C., 29 Dec. 1966

(Contract NSR-24-005-047)

(NASA-CR-84153; TR-67-340-1) CFSTI: HC \$3.00/MF \$0.65 CSCL 03B

A review is presented of the essential features of lunar cratering statistics and their interpretation in terms of the meteoroid impact hypothesis. The crater size distribution function is introduced. A simple model is used to discuss the concept of crater lifetime and the mechanisms for its limitation, with relevance to the existence of saturated surfaces and equilibrium distribution functions. Secondary cratering and its importance are considered. It is pointed out that several different theoretical models adequately match the measured distributions and that this argues against the exclusive justification of any one model. The conclusion is drawn that a nonequilibrium distribution function should contain information about the crater production process but that an equilibrium distribution may be sensitive primarily to local surface properties.

Author

N67-27297*# National Aeronautics and Space Administration, Washington, D. C.

**LUNAR SURFACE STUDIES—A CONTINUING
 BIBLIOGRAPHY WITH INDEXES**

Apr. 1967 66 p refs

(NASA-SP-7003(03)) CFSTI: HC \$3.00/MF \$0.65 CSCL 22A

A continuing bibliography on Lunar Surface Studies contains references to research in the theory of lunar origin, the lunar atmosphere and geological and topographical characteristics, lunar observation techniques, and instrumentation and equipment. The abstracts are presented chronologically, from February 1966 through January 1967, in two groups; those previously announced in the Scientific and Technical Aerospace Reports of NASA, and those from the International Aerospace Abstracts. Both a subject and an author index are included.

M.W.R.

N67-30593*# National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

ELECTRICAL POWER SYSTEMS STUDIES AT MSFC

Edward E. Dungan *In its Res. Achievements Rev.*, Vol. I 1967 15 p refs (See N67-30554 17-34)

Electrical power systems applicable to earth orbital and to lunar surface missions are discussed. Saturn Instrument Unit lifetime extensions will require fuel cells and/or radioisotopes for primary power. Lunar surface vehicles such as the Mobile Laboratory (MOLAB) will use fuel cells that must be optimized for mass savings. Two computer programs are discussed and one is described.

Author

N67-30609*# National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

ELECTRIC PROPULSION APPLICATION STUDIES AT MSFC

Joseph C. King *In its Res. Achievements Rev.*, Vol. I 1967 18 p refs

Recent work performed or sponsored by MSFC in the area of electric propulsion applications is summarized. The work reported is mainly in the mission study category, although a technology-type study of electric power conditioning systems is included. Two particular applications are treated, the lunar supply and manned Mars missions. Results are presented in the areas of trajectory analysis, vehicle design, and mission planning. The discussions given here are necessarily brief; a list of references for detailed information is provided.

Author

N67-30611*# National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

LUNAR PHYSICS AT MSFC

Gerhard B. Heller *In its Res. Achievements Rev.*, Vol. I 1967 16 p refs

The status of lunar surface mission studies, serving as a general background to the discussions of research achievements, are presented. Mechanical properties of simulated lunar materials are discussed. A thermal model of the lunar surface layers was analyzed, and potential lunar materials investigated in vacuum chambers. Computer programs were developed to allow a correlation of heat waves traveling into the moon and of the infrared radiation (IR) cooling and heating curves with microwave and IR measurements. Research continued on the bidirectional emittance of electromagnetic radiation, especially IR radiation. A computer study of the solar albedo radiation from the moon as it affected a lunar surface craft was mentioned, and design criteria and rocket exhaust impingement on simulated lunar surfaces were briefly outlined. Geological interpretations and mission planning were based on geophysical models.

R.LI

N67-30712# Lincoln Lab., Mass. Inst. of Tech., Lexington.

RADIO PHYSICS—DIVISION 3

Stephen H. Dodd and Melvin A. Herlin *In its Gen. Res.* 5 Jan. 1967 p 19-28 ref

Continued studies in the area of radio physics which are being conducted by the Millstone and Haystack facilities of the Millstone Hill Field Station are reported. Summarized are results of efforts to develop radar and radio astronomy techniques for satellite observations; ionospheric and auroral studies; and lunar studies.

S.C.W.

N67-30747*# Sandia Corp., Albuquerque, N. Mex.

PLANETARY QUARANTINE PROGRAM Quarterly Progress Report, Period Ending 30 Jun. 1967

H. D. Sivinski Jun. 1967 23 p
(NASA Order R-09-019-040; NASA Order H-13245A; NASA Order W-12324)
(NASA-CR-85573; QR-5) CFSTI: HC \$3.00/MF \$0.65 CSCL 06M

Program development and analysis and primary objectives for a planetary quarantine plan are related. Microbial death models and prediction of microbial burdens prior to sterilization are discussed. Surface sampling studies and experimentation in laminar flow environments are described. Also discussed are: an implementation system, experiments in ultrasonication, retrieval of terrestrial microorganisms from the lunar surface, and contamination control.
S.P.

N67-31351* American Science and Engineering, Inc., Cambridge, Mass.

PRELIMINARY OBSERVATIONS OF METEOR IMPACTS ON THE LUNAR SURFACE Final Report

J. Carpenter, G. Davidson, F. Franklin, and O. Shepherd [1967] 35 p refs
(Contract NASw-1413)
(NASA-CR-85817; ASE-1543) CSCL 03A

The feasibility of observing meteor impact on the lunar surface using a land based telescope and photo-electric detector pulse techniques is presented. An instrument to observe these impacts was designed and fabricated. Preliminary observations were performed at Lowell Observatory on a 20 inch refracting telescope during November 1966. The data for 19 November 1966, during which probable impacts were observed is presented. Author

N67-31378** Minnesota Univ., Minneapolis. Tycho Study Group.
LUNAR SURFACE ROUGHNESS SHADOWING AND THERMAL EMISSION

B. G. Smith Aug. 1966 28 p refs
(Contract NSR-24-005-047)
(NASA-CR-85830; TG-27) CFSTI: HC \$3.00/MF \$0.65 CSCL 03B

A statistical model of surface roughness is used in an attempt to understand the gross infrared emissive characteristics of the Moon. A self-shadowing theory of rough surfaces is developed which is relevant also, in a different context, to the determination of mean surface slope from shadow measurements, a technique of use in the analysis of Lunar Orbiter photographs. Author

N67-31397** Minnesota Univ., Minneapolis. Dept. of Electrical Engineering.

ON LUNAR "TEMPERATURES"

J. J. Hopfield Aug. 1966 14 p refs
(Contract NSR-24-005-047)
(NASA-CR-85850; TG-26) CFSTI: HC \$3.00/MF \$0.65 CSCL 03B

A lunar surface of part rock and part dirt is suggested by Luna IX and Surveyor I pictures. It is shown that the lunar night and eclipse temperatures are correctly predicted from the amount of rock observed in pictures if that rock is bare. The nature of the detectors used is an essential part of the calculation. In this model, eclipse hot spots are due to mean rock densities about five times the lunar surface average. The radio emission temperature measurements are not useful in distinguishing between this model and the conventional homogeneous surface models, at least with the signal/noise available at present. The failure to observe in the

radio emission the temperature dependence of dielectric loss is discussed.
Author

N67-31447* National Aeronautics and Space Administration, Washington, D. C.

SURVEYOR III PRELIMINARY SCIENTIFIC RESULTS PRESS BRIEFING

23 May 1967 133 p Available from the Scientific and Technical Information Division CSCL 03A

An overview of the Surveyor III capabilities and accomplishments is presented in this press briefing. Various photographs illustrate the lunar surface and measurements made by this Surveyor, which is located on the eastern shore of Oceanus Procarrum.
M.W.R.

N67-31836** Volt Technical Corp., Washington, D. C.
INVESTIGATION OF REFLECTIONS BY THE MOON'S SURFACE OF METER RADIO WAVES [ISSLEDOVANIYE OTRAZHENIY METROVYKH RADIOVOLN POVERKHNO-ST'YU LUNY]

O. I. Yakovlev and A. I. Yefimov 16 Jun. 1967 4 p refs
Transl. into ENGLISH from Dokl. Akad. Nauk SSSR (Moscow), v. 174, no. 3 p 583-584
(Contract NAS5-12487)
(NASA-CR-86662; ST-LPS-RWR-10626) CFSTI: HC \$3.00/MF \$0.65 CSCL 20N

Results of measurements of the reflection and scattering of radiowaves with $\lambda \approx 1.7$ m performed in September 1966 on the AMS Luna-11, are described. The dependency of the reflection factor on the sliding angle permitted data on the dielectric constant of lunar rocks to be obtained. A more extended report is to be presented elsewhere.
Author

N67-31851** Scientific Translation Service, La Canada, Calif.
POSSIBLE STRUCTURE OF LUNAR SURFACE LAYER [O VOZMOZHNOY STRUKTURE POVERKHNOSTNOGO SLOYA LUNY]

G. N. Dul'nev, Yu. P. Zarichnyak, and B. L. Muratova Washington, NASA, Jul. 1967 12 p refs Transl. into ENGLISH from Izv. Vyssh. Ucheb. Zaved., Radiofiz. (Gor'kiy), v. 9, no. 5, 1966 p 849-858
(Contract NASw-1496)
(NASA-TT-F-11071) CSCL 22A

The analytical expression for the effective thermal conductivity of bodies with a different structure is established. The solution of the opposite problem is investigated—determination of the body structure based on the effective thermal conductivity coefficient. Ideas on the possible structure of the lunar surface layer are presented. These ideas are based on an analysis of radio astronomical data on the magnitude of the parameter $\gamma = (\gamma \rho c)^{-1/2}$ and certain additional assumptions.
Author

N67-31934** Geological Survey, Washington, D. C.
ASTROGEOLOGIC STUDIES. PART A: LUNAR AND PLANETARY INVESTIGATIONS Annual Progress Report, 1 Jul. 1965-1 Jul. 1966

Dec. 1966 417 p refs
(NASA Order R-66)
(NASA-CR-86649) CFSTI: HC \$3.00/MF \$0.65 CSCL 22A

Reports on lunar maps, geologic studies, and on lunar and planetary physics are presented. For individual titles see N67-31935-N67-31955.

N67-31935*# Geological Survey, Washington, D. C.
SUMMARY OF THE GEOLOGY OF THE PITATUS REGION OF THE MOON

N. J. Trask and S. R. Tittley *In its Astrogeol. Studies, Part A* Dec. 1966 p 3-9 refs (See N67-31934 18-30)

Summarized are data on the stratigraphy and structure of the Pitatus region of the moon. S.C.W.

N67-31936*# Geological Survey, Washington, D. C.
THE GEOLOGY OF THE MARE SERENITATIS REGION OF THE MOON

M. H. Carr *In its Astrogeol. Studies, Part A* Dec. 1966 p 11-16 refs (See N67-31934 18-30)

Summarized are data on the stratigraphy and structure of the Mare Serenitatis region of the moon. S.C.W.

N67-31937*# Geological Survey, Washington, D. C.
GEOLOGIC HISTORY OF THE MARE HUMORIUM REGION OF THE MOON

S. R. Tittley *In its Astrogeol. Studies, Part A* Dec. 1966 p 17-21 refs (See N67-31934 18-30)

A discussion of the geologic history of the Mare Humorum region of the moon is presented and events leading to its formation are reviewed. S.C.W.

N67-31938*# Geological Survey, Washington, D. C.
SUMMARY OF THE GEOLOGY OF THE HEVELIUS REGION OF THE MOON

J. F. McCauley *In its Astrogeol. Studies, Part A* Dec. 1966 p 23-29 refs (See N67-31934 18-30)

Summarized are data on the stratigraphy, structure, and geologic history of the Hevelius region of the moon. A brief discussion of the Luna 9 landing site is included and speculation is made concerning the vicinity of the moon on which it landed. S.C.W.

N67-31939*# Geological Survey, Washington, D. C.
SUMMARY OF THE GEOLOGY OF THE COPERNICUS QUADRANGLE OF THE MOON

H. H. Schmitt, N. J. Trask, and E. M. Shoemaker *In its Astrogeol. Studies, Part A* Dec. 1966 p 31-39 refs (See N67-31934 18-30)

Geologic data on the Copernicus quadrangle of the moon are summarized; and stratigraphic characteristics of the complete quadrangle, the crater Copernicus, and the dark halo craters are discussed. S.C.W.

N67-31940*# Geological Survey, Washington, D. C.
SUMMARY OF THE GEOLOGY OF THE SELEUCUS QUADRANGLE OF THE MOON

H. J. Moore *In its Astrogeol. Studies, Part A* Dec. 1966 p 41-50 refs (See N67-31934 18-30)

Geologic data on the time-stratigraphic units of the Seleucus quadrangle of the moon are summarized. Analyzed are the pre-Imbrian units; the rock stratigraphic units spanning the Imbrian

and Eratosthenian systems; rock-stratigraphic units spanning the Eratosthenian and Copernican systems; and lineations and faults present in the Aristarchus plateau. S.C.W.

N67-31941*# Geological Survey, Washington, D. C.
GEOLOGY OF THE JULIUS CAESAR AND MARE VAPORUM QUADRANGLES

Don E. Wilhelms and Elliot C. Morris *In its Astrogeol. Studies, Part A* Dec. 1966 p 51-62 refs (See N67-31934 18-30)

Data on the stratigraphy and structure of the Julius Caesar and Mare Vaporum quadrangles are summarized. Described are: plains-forming materials; terra-mantling materials; materials with irregular surfaces; crater materials; concentric structures associated with the dominant basin structures in the two quadrangles; radial scarps and troughs; and minor structures consisting mainly of rilles (probably grabens) and some mare regions. The geologic history of the two quadrangles is also discussed. S.C.W.

N67-31942*# Geological Survey, Washington, D. C.
A COMPARISON OF TWO TERRESTRIAL GRABENS WITH THE LUNAR RILLES RIMA ARIADAEUS AND RIMAE HYPATIA I AND II

George I. Smith *In its Astrogeol. Studies, Part A* Dec. 1966 p 65-85 refs (See N67-31934 18-30)

Photogeologic maps were made of the fault systems related to two Quaternary grabens and were compared with maps of the inferred fault patterns in the vicinity of the lunar rilles Rima Ariadaeus and Rimae Hypatia I and II. Related characteristics of the lunar and terrestrial features are compared and on the basis of these data an attempt is made to determine tectonic origin. S.C.W.

N67-31943*# Geological Survey, Washington, D. C.
SEISMIC ENERGY AS AN AGENT OF MORPHOLOGIC MODIFICATION ON THE MOON

S. R. Tittley *In its Astrogeol. Studies, Part A* Dec. 1966 p 87-103 refs (See N67-31934 18-30)

A discussion of the endogenous seismicity of the moon and its possible role in producing morphological features and modifications of the lunar surface is presented. Surface seismic effects on the Earth and their relationship to those occurring on the Moon are also analyzed. Considered are the phenomena of compaction, slope failure or landslides, and debris creep. On the basis of comparison with terrestrial processes, it is concluded that: (1) seismic activity should be sufficient to produce many of the morphological features and modifications shown in Ranger and Surveyor I photographs; and (2) seismic activity may be a major modifying agent, although not necessarily the dominant one, and together with erosion by particles, may produce many of the features observed on the lunar surface. S.C.W.

N67-31944*# Geological Survey, Washington, D. C.
PRELIMINARY REPORT ON THE GEOLOGY OF THE PLATO QUADRANGLE OF THE MOON

J. W. McGonigle and D. L. Schleicher *In its Astrogeol. Studies, Part A* Dec. 1966 p 105-114 refs (See N67-31934 18-30)

Data on the morphological rock units, structure, and geologic history of the Plato quadrangle of the moon are summarized. S.C.W.

N67-31945*# Geological Survey, Washington, D. C.
PRELIMINARY GEOLOGIC SUMMARY OF THE CASSINI QUADRANGLE OF THE MOON

Norman J. Page *In its Astrogeol. Studies, Part A* Dec. 1966 p 115-121 refs (See N67-31934 18-30)

Stratigraphic relations and structural features of the Cassini quadrangle of the Moon are briefly described, and features that differ from previously described lunar relations and features are emphasized. S.C.W.

N67-31946*# Geological Survey, Washington, D. C.
PROBABLE IGNEOUS RELATIONS IN THE FLOOR OF THE CRATER J. HERSCHEL

G. E. Ulrich *In its Astrogeol. Studies, Part A* Dec. 1966 p 123-132 refs (See N67-31934 18-30)

Structural features in the floor of the crater J. Herschel are analyzed and an attempt is made to interpret observed features on the basis of a possible volcanic origin. S.C.W.

N67-31947*# Geological Survey, Washington, D. C.
STRUCTURE OF THE TRIESNECKER-HIPPARCHUS REGION
 T. W. Offield *In its Astrogeol. Studies, Part A* Dec. 1966 p 133-153 refs (See N67-31934 18-30)

More than 800 linear structures, including straight segments of curved lineaments, have been identified and measured in the Triesnecker-Hipparchus region near the center of the earthside hemisphere of the moon. The most common features are straight valleys between nearly linear ridges and the basis of straight escarpments. Other lineaments include rills, chain craters, mare ridges, and polygonal crater rims. Structural patterns observed are described and probable relationships of the local lineaments to distant mare basins, to a suggested lunar grid and to other regional structures, are defined and interpreted. S.C.W.

N67-31948*# Geological Survey, Washington, D. C.
THE THEORY OF RADIATIVE TRANSFER IN THE LUNAR SURFACE

Robert L. Wildey *In its Astrogeol. Studies, Part A* Dec. 1966 p 157-162 refs (See N67-31934 18-30)

Limitations of previously proposed methods for explaining infrared observations of the temperature variations of the lunar surface in terms of heat flow analysis are discussed. It is noted that the need for improvement of the theory of the heat flow of the lunar surface is independently founded on its failure to correctly predict recent infrared observations of lunar night-time cooling, even when temperature dependent conductivity and two layered models are used. A modified version of the fundamental equation of radiative transfer is developed for prescribing the behavior of the infrared radiation recorded on earth. It is concluded that the most satisfactory technique of solution appears to lie in the application of Chandrasekhar's method of discrete directional beams in Gaussian quadrature, so that the integro-differential equation will be replaced by a large number of simultaneous partial differential equations. S.C.W.

N67-31952*# Geological Survey, Washington, D. C.
THE PROCESSING OF PHOTOCLINOMETRIC DATA
 Alexander J. Swartz *In its Astrogeol. Studies, Part A* Dec. 1966 p 189-193 refs (See N67-31934 18-30)

A program focusing on the development of an improved system for processing photoclinometric data is reported. The primary goal of this system is to maximize the ratio of work done by the computer relative to manual reduction. Efforts to improve rapid processing techniques required to handle the large amounts of data available are described. Emphasized is an approach which involves the use of photometric scanning of the reconstructed photographs along phase lines to obtain data. Improvements to this technique are

discussed. Also discussed are programming difficulties stemming from differences in the isodensitracer magnetic tape output format and the input format required by the Fortran computer language; the use of a table look-up procedure in mapping via the photometric function; inherent problems associated with the manipulation of data by technical personnel; and the development of a device called a programmed light source for spatial microphotometry applications. S.C.W.

N67-31953*# Geological Survey, Washington, D. C.
THE NOCTURNAL HEAT SOURCES OF THE SURFACE OF THE MOON

Robert L. Wildey *In its Astrogeol. Studies, Part A* Dec. 1966 p 195-209 refs (See N67-31934 18-30)

A map of the thermal surface brightness of lunar regions darkward of the sunset terminator, together with a positional chart of a large number of nighttime hotspots, has recently been made by telescopic reconnaissance in the 8-14 μ region. Nine additional thermal anomalies and a morphological analysis of the signal properties of these anomalies are presented here. The extraction of information by this process has been carried to the limit allowed by system noise. Attempts to regain the cooling curves of anomalies themselves provide information suggestive that the anomalies are not all volcanic, a fact previously suspected but never observed directly. In addition it may be concluded that two categories of anomalies are present on the Moon's dark side, not including false anomalies of the delayed sunset type in which surface prominences are illuminated for some time after sunset on the surrounding lowlands. Author

N67-31955*# Geological Survey, Washington, D. C.
SUMMARY OF TELESCOPIC LUNAR STRATIGRAPHY
 Don E. Wilhelms *In its Astrogeol. Studies, Part A* Dec. 1966 p 237-305 refs (See N67-31934 18-30)

This paper summarizes the results of the lunar geologic mapping program of the U.S. Geological Survey as of mid-1966, when 28 quadrangles in the equatorial belt had been mapped by telescopic means at a scale of 1:1,000,000 and before mapping had begun at larger scales from photographs by unmanned lunar orbiters. The principles underlying lunar geologic mapping are discussed and an answer offered to the often asked question of how such mapping can be done before man sets foot on the Moon. Also discussed are nearly all stratigraphic units appearing on the published and preliminary maps produced and it is shown how the aforementioned general principles are applied in recognizing, defining, and naming individual units and placing them in order of relative age. The history and origin of these stratigraphic units as they were interpreted in mid-1966 is summarized. Author

N67-32582*# National Aeronautics and Space Administration
 Washington, D. C.
SURVEYOR III A Preliminary Report
 Jun. 1967 170 p refs
 (NASA-SP-146) CFSTI: HC\$3.00/MF\$0.65 CSCL 22B

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6. LUNAR THEORY AND PROCESSES D. Gault, R. Collins, T. Gold, J. Green, G. P. Kuiper et al p 141-156 refs (See N67-32588 18-30)

N67-32583*# National Aeronautics and Space Administration, Washington, D. C.

TELEVISION OBSERVATIONS FROM SURVEYOR III

E. M. Shoemaker, R. M. Batson, H. E. Holt, E. C. Morris, J. J. Gennilson et al *In its Surveyor III*, A Prelim. Rept. Jun. 1967 p 9-59 refs (See N67-32582 18-31)

Television pictures transmitted from lunar surface by Surveyor III showed small craters, linear ridges and troughs, and fragmental debris at random distribution. Degree of burial measurements on blocks in the lunar surface showed that their rounded tops above the surface had burial factors approaching 1, whereas rocks sitting on the surface had burial factors approaching 0. No significant linear correlation was established between roundness and burial depth for blocks in a given field. Size distribution of strewn fragments resembled the size distribution of fragments ejected from impact craters formed in strong rock. Imprints in the lunar surface material at touch-down points indicated that the fine-grain material was relatively incompressible. Photometric observation of the lunar surface established a luminescence factor of about 8.5% for the undisturbed area. Calorimetric measurements showed a relatively uniform gray color for the undisturbed surface. Included were also photographs of earth pictures telemetered from the spacecraft.

G.G.

N67-32584*# National Aeronautics and Space Administration, Washington, D. C.

SOIL MECHANICS SURFACE SAMPLER: LUNAR SURFACE TEST AND RESULTS

R. F. Scott, F. I. Roberson, and M. C. Clary *In its Surveyor III*, A Prelim. Rept. Jun. 1967 p 61-93 (See N67-32582 18-31)

Results of tests performed by the soil sampler on the lunar surface are presented together with some conclusions on the mechanical properties of the surface material, as deduced from test materials. Brief evaluation of the soil sampler behavior and photographic results indicated a possibility that the lunar material becomes stronger and denser with depth. Bearing tests under a high Sun angle showed that soil disturbance took place to a distance of 10 to 12.5 cm; impact tests from a drop height of 60 cm compared with similar laboratory tests on densely packed dry sand.

G.G.

N67-32585*# National Aeronautics and Space Administration, Washington, D. C.

LUNAR SURFACE MECHANICAL PROPERTIES

E. M. Christensen, S. A. Batterson, H. E. Benson, R. Choate, L. D. Jaffe, et al *In its Surveyor III*, A Prelim. Rept. Jun. 1967 p 94-120 refs (See N67-32582 18-31)

Mechanical properties of the lunar surface at the Surveyor III landing site appeared to be similar to those at the Surveyor I site. Lunar soil static bearing capability was determined as 2×10^5 to 5.5×10^5 dynes/cm² for a penetration depth of 2.5 to 5 cm and for an area equivalent to that of a footpad. Footpad imprint simulations suggested that the lunar surface material contains substantial amounts of particles finer than sand grains. Imprints and soil throwout patterns indicated a low compressibility of the lunar surface material. An upper bound for lunar soil cohesion

was determined from the bearing strength as less than 1.4×10^5 dynes/cm² at a depth of about 20 cm. Spacecraft oscillations following the landing projected a rigidity modulus and shear wave velocity lower than those for loose terrestrial sand.

G.G.

N67-32586*# National Aeronautics and Space Administration, Washington, D. C.

LUNAR TEMPERATURES AND THERMAL CHARACTERISTICS

J. W. Lucas, J. E. Conel, W. A. Hagemeyer, C. B. Jones, J. M. Saari et al *In its Surveyor III*, A Prelim. Rept. Jun. 1967 p 121-137 refs (See N67-32582 18-31)

Outer canister temperatures of two electronic compartments on Surveyor III were used to estimate the average brightness temperature of those portions of the lunar surface viewed by the compartments. Observed lunar surface temperatures were in good agreement with predicted values around noon and comparable to a homogeneous surface model with thermal inertia greater than 400. During the afternoon, compartment temperatures were somewhat higher than expected from Earth-based data. Both compartments saw the same lunar surface temperature throughout all the the umbral and almost all of both penumbral phases; this indicated nondirectional lunar surface emission at low insulation.

G.G.

N67-32587*# National Aeronautics and Space Administration, Washington, D. C.

LUNAR SURFACE ELECTRICAL PROPERTIES

W. E. Brown, R. A. Dibos, G. B. Gibson, D. O. Muhleman, W. H. Peake et al *In its Surveyor III*, A Prelim. Rept. Jun. 1967 p 139 (See N67-32582 18-31)

Radar (radar altimeter and doppler velocity sensor) preliminary results for Surveyor III indicate that the radar cross section (rxs) for the 25° off-nominal and vertical beams were approximately the same as those obtained from the Surveyor I data and Earth-based measurements. The rxs values of -12 db for the 25° beams for regions external to the crater in which the spacecraft landed and -8 to -4 db for the vertical beam yield an estimate of the relative dielectric constant as $\epsilon = 3.7 \pm 0.5 / -1.0$. These measurements and estimates coupled with Earth-based measurements of the factors of microwave phase lag angle (40°), thermal parameter (1420), and specific heat (0.2) allow a value for the ratio of the electrical loss tangent to density to be computed as $\tan \phi / \rho = 2.57 \times 10^{-2} \pm 20\%$.

Author

N67-32588*# National Aeronautics and Space Administration, Washington, D. C.

LUNAR THEORY AND PROCESSES

D. Gault, R. Collins, T. Gold, J. Green, G. P. Kuiper et al *In its Surveyor III*, A Prelim. Rept. Jun. 1967 p 141-156 refs (See N67-32582 18-31)

Preliminary evaluation of Surveyor mission information gained data on physical and mechanical properties of the surficial layer of the lunar surface from the soil surface sampler and from an unprogrammed multiple landing sequence. An absence of adhesion forces was established through the clean operation of the soil sampler. Surveyor pictures of strewn rock formations indicated rounded shapes and downhill movement of the fine material of the lunar surface layer. The dielectric constant for the observed lunar surface corresponded to known values of clear silica glass, namely 3.8.

G.G.

N67-33163* Geological Survey, Washington, D. C.
ASTROGEOLOGIC STUDIES. PART B: CRATER INVESTIGATIONS Annual Progress Report, 1 Jul. 1965-1 Jul. 1966

Nov. 1966 288 p refs
(NASA Order R-66)
(NASA-CR-87057) CSCL 08G

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N67-33174* Geological Survey, Washington, D. C.
GEOLOGY OF THE MOSES ROCK INTRUSION, SAN JUAN COUNTY, UTAH

Thomas R. McGetchin *In its Astrogeol. Studies*, Pt. B Nov. 1966 p 231-253 refs (See N67-33163 19-13)

The Moses Rock intrusion was studied as a possible analog to the subsurface geology of lunar rilles, and the details on the structure of the dike are discussed and presented in maps. The lithologically distinct breccia units are described as mixtures of kimer kimberlite-serpentine breccia, inclusions of Precambrian metamorphic and igneous rock fragments, and inclusions of sedimentary rocks. Graphs of particle size distributions are included. The inferred history of emplacement is illustrated and briefly discussed. N.E.N.

N67-33422* National Aeronautics and Space Administration.
Manned Spacecraft Center, Houston, Tex.

ULTRAVIOLET CALIBRATION PROCEDURES FOR GEMINI EXPERIMENT M-407

Roy C. Stokes and John E. Novotny Jul. 1967 35 p refs
(NASA-TM-X-58009) CFSTI: HC \$3.00/MF \$0.65 CSCL 20F

Ultraviolet radiometric calibration and data analysis techniques were developed for Gemini inflight experiment M-407. The object of the experiment was to measure the spectral albedo of the moon between 2000 and 3200 Å using an objective grating spectrograph. Because of unfavorable phase angles of the moon during Gemini flights X, XI, and XII, the experiment could not be conducted. However, considerable effort was devoted to the project in the areas of technique development related to performance and evaluation of the in-flight measurements. A brief summary of the

experiment with a description of the hardware, the ultraviolet calibration techniques, and the data reduction techniques developed for the experiment are given. Author

N67-34489* Scientific Translation Service, La Canada, Calif.
SURFACE LAYER OF THE MOON [POVERKHNOSTNYY SLOY LUNY]

A. A. Gurshteyn Washington, NASA, Aug. 1967 24 p Transl. into ENGLISH from Priroda (Moscow), no. 6, Jun. 1967 p 1-15
(Contract NASw-1496)
(NASA-TT-F-11210) CSCL 03B

Information on the moon derived by astronomers is summarized. Data on the spacecraft sent to the moon in the last eight years are given, starting with Luna-1 in 1959 and including the American spacecraft in the Lunar Orbiter, Ranger, and Surveyor series. Author

N67-34542* Cornell Aeronautical Lab., Inc., Buffalo, N. Y.
PROJECT TECH TOP STUDY OF LUNAR, PLANETARY AND SOLAR TOPOGRAPHY Final Report

D. A. Richards, J. D. Gallatin, and R. O. Breault Jul. 1967 350 p refs
(Contract NAS12-19)
(NASA-CR-85008; VC-2104-D-2) CFSTI: HC \$3.00/MF \$0.65 CSCL 03B

A program to assess the state of the art and to make recommendations for future research in topographic information collection systems for planetary and solar investigation is discussed. Continued analysis of planetary topography to include the initiation of a detailed system analysis, a review and analysis of image restoration processes and their application to space imagery, and some mapping considerations for a stereo imagery system are presented. Three major aspects of solar topography, theoretical, engineering and experimental, were investigated. The theoretical aspects concerned the concepts, phenomena and problems of major importance to the study of the sun. The engineering aspects concerned solar probe feasibility and survivability, the use of cooperating vehicles, and earth-based solar instrumentation. Two experimental possibilities were examined involving the use of an active backscatter probe of the sun and the use of Fourier transform spectroscopy in space. Specific recommendations for future research and experimentation and a bibliography are included. Author

N67-34631* National Aeronautics and Space Administration.
Manned Spacecraft Center, Houston, Tex.

PRELIMINARY INVESTIGATION OF A LUNAR "ROLLING STONE"

J. M. Eggleston, A. W. Patteson, J. E. Throop, W. H. Arant, and D. L. Spooner Mar. 1967 14 p refs
(NASA-TM-X-58007) CFSTI: HC \$3.00/MF \$0.65 CSCL 03B

Based on Orbiter II photographic analyses, a preliminary investigation was made of boulders which appeared to have rolled down the interior wall of the lunar crater, Sabine D, in the southwestern area of Mare Tranquillitatis. Stereoscopic measurements were taken of the path to determine the crater's depth; a microdensitometer was used to confirm measurements of the dimensions of the boulder and the track down the crater wall. Initial data indicate: (1) Large, cohesive, and near-spherical boulders exist on the lunar surface. (2) At least a few lunar boulders have moved or have been moved recently enough so that their tracks have not been obliterated by lunar erosion processes. (3) One such boulder, whose reflectance properties were analyzed by microdensitometer measurements, appears to reflect as a Lambert

surface. (4) The wall of Sabine D. with a slope of about 30°, appears to be covered with a compressible material which failed under the pressure of the boulder as it moved down the slope.
M.G.J.

N67-34775*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
LUNAR AND PLANETARY SCIENCES
In its Space Programs Sum. No. 37-45, Vol. IV 30 Jun. 1967
p 235-243 refs (See N67-34761 20-30)

To provide an experimental basis for the geologic interpretation of spectral reflectance measurements of planetary surfaces, laboratory studies were made of particulate rocks. Changes in the wavelength distribution of reflected light were measured as functions of rock composition and mineralogy, particle size, particle shape, particle packing, and angle of illumination. Experimental results indicate that powdered silicate rocks can be classified as rock glasses, crystalline acidic rocks, or crystalline basic-ultrabasic rocks, on the basis of spectral reflectance in the 0.4 to 2.0 μ wavelength region. This led to the conclusion that a combination of several spectral reflectance properties is capable of giving some gross composition information on silicate rock powders. Summary data are provided on determinations of cloud-top pressure and hydrogen abundance in the Jupiter atmosphere. Also considered are four methods of analyzing the visible and near-infrared spectrum of solar energy returned from the lunar surface: photometry, polarimetry, luminescence, and spectrophotometry. Pictorial data are included to show the linear Martian features obtained from Mariner IV photographs.
M.G.J.

N67-35071*# Bureau of Mines, Minneapolis, Minn. Twin Cities Mining Research Center.
MULTIDISCIPLINARY RESEARCH LEADING TO UTILIZATION OF EXTRATERRESTRIAL RESOURCES Annual Status Report, Fiscal Year 1967
1967 74 p refs
(NASA-Order R-09-040-001)
(NASA-CR-88161) CFSTI: HC \$3.00/MF \$0.65 CSDL 22A

Experimental work is reported for various physical and engineering property data on lunar surface materials, the development of the Apollo lunar drills, and the planning of the Apollo lunar scientific experiments. Particular effort is placed on the study of data from lunar soft-lander and orbiter probes to establish the range of rock materials most likely to be encountered on the Moon. Also reported is a literature search related to the program's objectives.
G.G.

N67-35541*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
COMPARATIVE LUNAR-TERRESTRIAL COLORIMETRY
R. M. Hively and J. K. Westhusing (Lockheed Electron. Co.)
[1966] 41 p refs
(NASA-TM-X-58008) CFSTI: HC \$3.00/MF \$0.65 CSDL 03A

The postulated use of lunar-surface colorimetry to establish surface composition and rock type is evaluated in this paper. The study examines the methods of measuring color, a brief history of lunar color observations, the limitations of lunar colorimetric studies, and the results of a laboratory colorimetric study of terrestrial materials. The resulting data are correlated with colorimetric data from selected lunar regions. From these comparisons it was concluded that: (1) spectrophotometric curves are necessary to make meaningful correlations between the colorimetric properties of lunar and terrestrial materials; (2) several terrestrial volcanic rocks exhibit colorimetric similarities to lunar surface areas; (3) the statistical approach offers the best correlation between rock type and color

and, from this, a correlation with lunar surface color; and (4) pulverizing samples to smaller particle size causes increased brightness and increased sample redness.
Author

N67-36215*# Hughes Aircraft Co., Los Angeles, Calif.
THE SURVEYOR THERMAL SWITCH
T. E. Deal *In* JPL 2d Aerospace Mech. Symp. 15 Aug. 1967
p 93-100 (See N67-36203 21-31)

The external temperature extremes of the lunar surface dictated that a means be found to control the two electronic compartments on the Surveyor soft lunar landing vehicle within a narrower temperature band to assure satisfactory component performance. Accordingly, thermal switches were developed to conduct heat away from temperature-sensitive components while heat-generating components were operating during the lunar day, and to retain heat at night when the equipment was off.
Author

N67-36661* Volt Technical Corp., Washington, D. C.
MEASUREMENTS OF GAMMA RADIATION OF THE LUNAR SURFACE ON THE SPACE STATION LUNA-10
A. P. Vinogradov, Yu. A. Surkov, G. M. Chernov, F. F. Kirnozova, and G. B. Nazarkina 31 Aug. 1967 25 p refs
(Contract NAS5-12487)
(NASA-CR-88277; ST-LPS-ACH-10643) CSDL 03B

Data are presented which complete the preliminary results of lunar gamma radiation measurements conducted with the aid of the scintillation gamma spectrometer installed on LUNA-10. Also included are new data on the spectral composition and the results of gamma radiation intensity measurements above different regions of the lunar surface. This is preceded by a thorough review of all possible sources of lunar gamma radiation. The types of lunar rocks are determined by the gamma radiation due to the natural radioactive elements contained in them. On the basis of these results it is confirmed that the rocks of lunar continental regions are probably represented by ultrabasic (chondritic) formations or by a mixture of basic and ultrabasic rocks, while the maria are composed of rocks similar to terrestrial basalts.
Author

N67-36772*# IIT Research Inst., Chicago, Ill. Technology Center.
COMPOSITIONAL ANALYSIS OF LUNAR AND PLANETARY SURFACES USING NEUTRON CAPTURE GAMMA RAYS
Annual Report, May 1, 1966-June 30, 1967
John H. Reed 1 Jul. 1967 102 p refs
(Contract NASr-65(18))
(NASA-CR-88485; IITRI-A6155-5) CSDL 03B

Computer calculations were performed using the one-dimensional DTK neutron transport computer code assuming an isotropic 14-MeV neutron source on the surface of a large sample. The results predicted that the flux of thermal neutrons increases with depth and reaches a maximum at about 90 gm/cm² below the surface of the sample. If a paraffin reflector a few centimeters in thickness is placed above the 14-MeV neutron source, the thermal flux at the surface is greatly increased, and has its maximum value there. These predictions were verified experimentally by measuring the thermal flux distribution in a large sand sample both with and without a reflector above the 14-MeV neutron source. A parametric study was made to determine the effects of variables on the sensitivity of the capture gamma ray technique. Results established the feasibility of applying the technique to the analysis of semi-infinite samples.
Author

N67-37082*# Arizona Univ., Phoenix.
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY, NUMBERS 79-81, VOLUME 6, PART 1

1967 87 p refs
(Grant NSG-161)
(NASA-CR-88749) CSDL 03B

Reports on laboratory experiments and astronomical observations are presented. Lunar crater counts and lunar cratering are discussed, and the Leonid meteor shower of November 17, 1966, is described. Photometric data of the eclipse reappearances of satellites Jupiter I, II, and III, and of T Tauri stars are given. Observations of plane interstellar polarization and the wavelength dependence of the interstellar polarization are reviewed. The development and preparation of solid organic filters using a polymethyl siloxane resin are outlined. Laboratory experiments for detecting small amounts of various gases that may occur in planetary atmospheres are mentioned. N.E.N.

N67-37328*# TRW Systems, Redondo Beach, Calif.
SITE ACCESSIBILITY ANALYSIS FOR ADVANCED LUNAR MISSIONS VOL. I: SUMMARY. Final Report

H. Patapoff 30 Jun. 1967 102 p refs
(Contract NAS9-4810; Project Apollo)
(NASA-CR-65728; TRW-05952-H223-RO-00, Vol. I; TRW-67-FMT-521, Vol. I) CFSTI: HC \$3.00/MF \$0.65 CSDL 22A

A simplified and relatively rapid mission analysis procedure for determining approximate lunar areas of accessibility for mission planning purposes is presented. The procedure consists of three basic steps: 1) the determination of the various geometrical constraints upon site accessibility, 2) the determination of the ΔV constraints or requirements upon accessibility, and 3) the graphical procedure which consists of the manipulation or interpretation of the results of the first two steps to provide the answer or data for the specific mission under consideration. A discussion of these basic steps is given along with the detailed procedure for two example cases. The translunar and transearth velocity data presented and used in the graphical procedure, represent optimized two-impulse transfers to and from the moon. These transfers provide considerable savings in SM fuel when compared with single impulse transfers presently planned for the Apollo missions. The mission analysis procedure is independent of the mode of orbit transfer and its only requirement is that the velocity data be in the proper format. R.N.A.

N67-37577*# Litton Systems, Inc., Minneapolis, Minn. Applied Science Div.

INVESTIGATION OF SPUTTERING EFFECTS ON THE MOON'S SURFACE Final Report, 25 Apr. 1963-2 Jun. 1967

G. K. Wehner and C. E. Ken Knight 1 Jun. 1967 51 p refs
(Contract NASw-751)
(NASA-CR-88738; Rept.-3107) CFSTI: HC \$3.00/MF \$0.65 CSDL 03B

Research from 1963 to 1967 on effects of solar-wind bombardment of the lunar surface is summarized. Erosion due to sputtering by the solar wind is not estimated to be 2 cm in a 4.5×10^9 yr history at current rates. Studies on lunar optical properties in comparison with ion-bombarded powder samples imply a low density surface of insulating (non-metallic) particles mostly less than 0.1 mm in diameter. Surveyor photographs are consistent with formation of a powder layer of at least meter thickness by meteoritic bombardment. Albedo contrast between rocks and powder in that layer is consistent with darkening of the powder by the solar wind or some other external agent or with marked differences in two rock sources contributing to that layer. Cementation of the lunar surface powder, now confirmed by Surveyor data, was suggested by cementation of ion-bombarded powder samples in simulation experiments. Author

N67-37651*# Geological Survey, Washington, D. C.
ASTROGEOLOGIC STUDIES. PART D: SPACE FLIGHT INVESTIGATIONS Annual Progress Report, 1 Jul. 1965-1 Jul. 1966

Dec. 1966 93 p refs
(NASA Order R-66)
(NASA-CR-88532; APR-7) CFSTI: HC \$3.00/MF \$0.65 CSDL 03B

Included are reports on geologic analysis and mapping from Ranger photographs, research on methods of Ranger photogrammetry, an analysis of small lunar craters by comparison with experimentally produced impact and explosion craters, and a sample of the preflight geologic reports prepared for the sites photographed by Lunar Orbiter I. Author

N67-37905*# Volt Technical Corp., Washington, D. C.
FIRST PANORAMAS OF LUNA-13. DETERMINATION OF DENSITY AND MECHANICAL STRENGTH OF LUNAR LAYER AT THE LANDING SITE OF THE AUTOMATIC STATION LUNA-13

I. I. Cherkasov, A. L. Kemurdzhian, L. N. Mikhaylov, V. V. Mikheyev, A. A. Morozov et al 25 Aug. 1967 30 p refs Transl. into ENGLISH from the Russian preprint
(Contract NAS5-12487)
(NASA-CR-88874; ST-LPS-LSL-10640) CSDL 03B

Twelve lunar surface panoramas and data obtained from the Soviet automatic station Luna 13 indicate that its landing site was a layer of granular material with volumetric weight of 0.8 g/cm³ or somewhat less. This layer consisted of grains and granules of porous mineral material that are loosely connected. Thickness of the layer at the groundmeter-penetrometer is considered to be not less than 5 cm, and numerous stones are thought to be scattered over the landing site. Details of the penetrometer are included, as are those for the radiation densimeter, which was designed to measure density of the upper layer of the lunar soil. Installation of devices on Luna 13 and landing of the instrumentation package are discussed. M.W.R.

N67-37973*# IIT Research Inst., Chicago, Ill. Technology Center.
COMPOSITIONAL ANALYSIS OF LUNAR AND PLANETARY SURFACES USING NEUTRON CAPTURE GAMMA RAYS

John H. Reed 22 Mar. 1967 15 p
(Contract NAS-67(18))
(NASA-CR-88503; IITRI-A6155-3) CSDL 03B

The objective of this research program is to establish the practicality of using neutron capture gamma rays as a part of NASA's combined neutron experiment for lunar and planetary surface analysis. This requires (1) the determination of the sensitivity of the technique under reasonable field conditions with the experimental configuration optimized for the capture gamma-ray technique and (2) the determination of the effects which integration with other neutron techniques will have on its sensitivity. Capture gamma-ray spectra were studies from a large sample using a pulsed 14 MeV neutron source under a variety of experimental conditions. It has been determined that horizontal detection geometry yields better sensitivity than does vertical geometry and that a moderating material above the neutron source (about 4 to 8 cm thick) greatly increases the sensitivity of the capture gamma-ray technique. Author

N67-38161*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SURVEYOR III MISSION REPORT. PART II: SCIENTIFIC RESULTS

1 Jun. 1967 222 p refs
(Contract NAS7-100)
(NASA-CR-88952; JPL-TR-32-1177) CFSTI: HC \$3.00/MF \$0.65 CSDL 22A

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2. TELEVISION OBSERVATIONS FROM SURVEYOR III E. M. Shoemaker, R. M. Batson, H. E. Holt, E. C. Morris, J. J. Rennilson et al p 9-66 refs (See N67-38163 23-30)
3. SOIL MECHANICS SURFACE SAMPLER: LUNAR SURFACE TESTS, RESULTS, AND ANALYSES R. F. Scott and F. I. Roberson p 69-110 ref (See N67-38164 23-30)
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5. LUNAR TEMPERATURES AND THERMAL CHARACTERISTICS J. W. Lucas, J. E. Conel, R. R. Garipay, W. A. Hagemeyer, C. B. Jones et al p 155-187 refs (See N67-38166 23-30)
6. LUNAR SURFACE ELECTRICAL PROPERTIES W. E. Brown, Jr., R. A. Dibos, G. B. Gibson, D. O. Muhleman, W. H. Peake et al p 189-194 refs (See N67-38167 23-30)
7. LUNAR THEORY AND PROCESSES D. Gault, R. Collins, T. Gold, J. Green, G. P. Kuiper et al p 195-213 refs (See N67-38168 23-30)

N67-38162*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

PRINCIPAL SCIENTIFIC RESULTS OF THE SURVEYOR III MISSION

L. D. Jaffe, S. A. Batterson, W. E. Brown, Jr., E. M. Christensen, D. E. Gault et al *In its Surveyor III Mission Rept. Pt. II*, 1 Jun. 1967 p 3-7 (See N67-38161 23-30)

Mechanical properties of lunar surface materials and microscopic features of the local terrain are among the scientific results reported for the Surveyor III mission. Characteristics of the local microstructure are noted, along with effects of engine exhaust and the nonstatic nature of the lunar surface. The relation of properties at the Surveyor I and Surveyor III landing sites are indicated, and some general astronomical observations are reported.

M.W.R.

N67-38163*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

TELEVISION OBSERVATIONS FROM SURVEYOR III

E. M. Shoemaker, R. M. Batson, H. E. Holt, E. C. Morris, J. J. Rennilson et al *In its Surveyor III Mission Rept. Pt. II*, 1 Jun. 1967 p 9-66 refs (See N67-38161 23-30)

Operating characteristics and categories of new information provided by television pictures are reviewed along with a description of the television camera used aboard Surveyor III. Location of Surveyor III on the moon is noted and several photographs and topographic maps are included to indicate the landing site topography and spacecraft attitude. The small craters, patterned ground, and fragmented debris at the landing site are discussed and the lunar surfaces disturbed by Surveyor III are reported. Geological interpretation of these lunar terrain data are presented, including the origin of the observed craters and fragmented debris, the creep of lunar regolith, and the processes leading to diversity of albedo. Photometric and colorimetric observations of lunar surface are reported, as are the eclipse of the sun by the earth and the partially illuminated earth as seen from Surveyor III.

M.W.R.

N67-38164*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

SOIL MECHANICS SURFACE SAMPLER: LUNAR SURFACE TESTS, RESULTS, AND ANALYSES

R. F. Scott and F. I. Roberson *In its Surveyor III Mission Rept. Pt. II*, 1 Jun. 1967 p 69-110 ref (See N67-38161 23-30)

Subsystems and functional descriptions are given for the soil mechanics surface sampler that was modified for use aboard Surveyor III. Originally planned strain, acceleration, and position

measuring systems were removed in favor of a means of measuring current drawn by the motors. The extension/retraction mechanism, drive system, scoop, and motor control are described; as are engineering performance and lunar surface operations of the sampler. Lunar surface materials tests performed dealt with bearing, trenching, impact, material handling and dumping, and determination of homogeneity of the lunar soil and the depth variation of lunar soil properties.

M.W.R.

N67-38165*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

LUNAR SURFACE MECHANICAL PROPERTIES

E. M. Christensen, S. A. Batterson, H. E. Benson, R. Choate, L. D. Jaffe et al *In its Surveyor III Mission Rept. Pt. II*, 1 Jun. 1967 p 111-153 refs (See N67-38161 23-30)

Landing impacts, telemetry data from Surveyor III, and a comparison with Surveyor I data form the basis for interpretational analyses of the mechanical properties of the lunar surface. Landing, footpad/surface interactions, vernier engine effects, auxiliary mirrors, and the attitude control jet experiment are discussed. Simulated landing studies and footpad imprint simulations are included, and pictures of the latter are analyzed. Reflective properties of the lunar soil, estimations of soil parameters, elastic properties of lunar soil, camera mirror contamination versus vernier erosion, and a strength estimate of lunar rock are reported.

M.W.R.

N67-38166*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

LUNAR TEMPERATURES AND THERMAL CHARACTERISTICS

J. W. Lucas, J. E. Conel, R. R. Garipay, W. A. Hagemeyer, C. B. Jones et al *In its Surveyor III Mission Rept. Pt. II*, 1 Jun. 1967 p 155-187 refs (See N67-38161 23-30)

Surveyor III data on lunar surface temperatures, thermophysical characteristics, and spacecraft thermal performance on the lunar surface are reported. Since the spacecraft carried no specific instrumentation to measure lunar surface temperature, outer canister temperatures of the electronic compartments were used to estimate average brightness. Thermophysical properties of the Surveyor III site are discussed as determined by earth-based data. Attention is given to directional effects of lunar infrared emission, the spacecraft view of the lunar surface, and spacecraft raw data. Shading effects on compartments are discussed and both Lambertian and directional lunar surface temperature calculations are included. Tentative conclusions from the lunation data indicate that lunar surface temperatures measured by both Surveyors are in good agreement around noon and compatible with a homogeneous surface model with thermal inertia greater than 400. Differences between compartment temperatures during the morning are explained by different local lunar surface sun phase angles and by directional thermal emission. Based on the correspondence of lunar surface brightness temperatures obtained by Surveyors I and II, it is concluded that there is no thermally significant dust on the compartment faces.

M.W.R.

N67-38167*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

LUNAR SURFACE ELECTRICAL PROPERTIES

W. E. Brown, Jr., R. A. Dibos, G. B. Gibson, D. O. Muhleman, W. H. Peake et al *In its Surveyor III Mission Rept. Pt. II*, 1 Jun. 1967 p 189-194 refs (See N67-38161 23-30)

Radar altimeter and doppler velocity sensor measurements by Surveyor III indicate radar cross sections for the 25-deg off-normal vertical beams to be approximately the same as those obtained with Surveyor I. The relative dielectric constant for the regions external to the crater where Surveyor III landed is estimated at 3.5 ± 0.7 .

M.W.R.

N67-38168* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
LUNAR THEORY AND PROCESSES
 D. Gault, R. Collins, T. Gold, J. Green, G. P. Kuiper et al. *In its*
Surveyor III Mission Rept. Pt. II, 1 Jun. 1967 p 195-213 refs
 (See N67-38161 23-30)

Position of the lunar surface and properties of the lunar surface layer are considered in terms of preliminary data reduced from the Surveyor III mission. Consideration is given to the general morphology of the lunar landing site, evidence for downhill material transport, and the lunar dielectric constant. Preliminary data evaluation give information about the relation between the surface material responsible for the photometric properties and the deeper layers of material in which the properties resemble those of ordinary terrestrial soils. M.W.R.

N67-38197* Cornell Univ., Ithaca, N. Y. Center for Radiophysics and Space Research.

PHOTOMETRIC AND OTHER LABORATORY STUDIES RELATING TO THE LUNAR SURFACE

Bruce Hapke [1967] 27 p refs Sponsored also by General Motors Corp.
 (Grant NSG-382)

(NASA-CR-89078) CFSTI: HC \$3.00/MF \$0.65 CSCL 03B

The reflecting characteristics of a wide variety of surfaces were investigated in order to determine the properties which are essential for lunar type scattering. Results of the photometric measurements on the intensity of light reflection indicate that in order to backscatter light as strongly as the moon does, its material must have not only an extremely porous and open structure, but the cavities in the surface must also be interconnected. The data indicate that the lunar surface is covered to an unknown depth by a layer of rock dust whose particles have an average size of about 10μ . The grains of rock are probably darkened by exposure to solar radiation and arranged by micrometeorite bombardment into a porous material with a bulk density only one-tenth that of solid rock. L.S.

N67-38369* Boeing Co., Seattle, Wash.

LUNAR ORBITER II: PHOTOGRAPHIC MISSION SUMMARY

Washington, NASA, Oct. 1967 93 p

(Contract NAS1-3800)

(NASA-CR-883; D2-100752-1) CFSTI: HC \$3.00/MF \$0.65 CSCL 22B

The spacecraft launching, systems performance, and mission data are discussed in detail. The tracking and maneuvers during flight are described. The operational performance of the spacecraft and the worldwide command, control, and data recover systems are presented. The environmental, tracking, and performance data are reviewed, and the photographic data of 13 primary and 17 secondary sites are emphasized. High quality wide angle and oblique photos were obtained, and many photographs are included. Also reported are improvement in orbit determination and prediction accuracy, concurrent recording of orbiter transmissions, techniques for accurately positioning the spacecraft to the oblique photographs, and successful temperature control integrated into the operational sequence. Three micrometeoroid impacts were also recorded, with no noticeable effects on spacecraft performance. N.E.N.

N67-38932* Volt Technical Corp., Washington, D. C.

NEUTRON RADIATION OF THE MOON INDUCED BY COSMIC RAYS [NEYTRONNOYE IZLUCHENIYE LUNY VYZVANNOYE KOSMICHESKIMI LUCHAMI]

V. F. Zakharchenko 5 Oct. 1967 4 p refs Transl. into ENGLISH from *Izv. Akad. Nauk SSSR, Ser. Fiz. (Moscow)*, v. 30, no. 11, 1966 p 1813-1814

(Contract NAS5-12487)

(NASA-CR-89297; ST-LPS-CR-10651) CSCL 20H

This note shows how the results of measurements of the neutron flux near the surface of the moon provide the possibility in principle of deriving conclusions as regards to at least the relative chemical composition of its surface layer. Author

N67-39074* IIT Research Inst., Chicago, Ill. Technology Center.

COMPOSITIONAL ANALYSIS OF LUNAR AND PLANETARY SURFACES USING NEUTRON CAPTURE GAMMA RAYS, JULY 1, 1967-SEPTEMBER 30, 1967

John W. Mandler and John H. Reed 11 Oct. 1967 28 p

(Contract NASr-65(18))

(NASA-CR-89330; IITRI-A6155-6) CSCL 03B

The practicability of using neutron capture gamma rays as a part of NASA's combined neutron experiment for lunar and planetary surface analysis is under investigation. This requires the determination of (1) the feasibility of performing an elemental analysis on a semi-infinite material by means of the capture gamma-ray technique using a pulsed 14-MeV neutron source, (2) the effect on sensitivity of integration with the other neutron techniques, and (3) the sensitivity of the technique under reasonable field conditions. Earlier results indicated that elemental analysis is feasible using thermal neutron capture gamma rays induced by a pulsed source of 14-MeV neutrons. Work done to alleviate the problem areas is described. The inefficient use of neutrons was eliminated by reducing the neutron output per pulse to approximately the output expected in the neutron generator. Lowering the neutron output and changing amplifiers reduced the spectrum degradation and allowed sampling to begin 10 μ sec after the end of the neutron burst. The iron-sand sample was replaced by a homogeneous sample of crushed granite. Author

N67-39341* National Aeronautics and Space Administration, Washington, D. C.

PRELIMINARY SCIENTIFIC RESULTS FROM SURVEYOR V News Release

29 Sep. 1967 60 p

Available from the Scientific and Technical Information Division CSCL 22A

A NASA news release on the preliminary scientific results obtained from the Surveyor V soft touchdown on the lunar surface on September 10, 1967, is presented. Photographic and chemical (using an alpha backscattering instrument) data are discussed. The data are discussed with respect to the topography, geology, mechanical properties, chemical composition, and magnetic properties of the lunar surface. Implications of the data on lunar theory are discussed. Numerous closeup photographs of the lunar surface taken from the Surveyor V are depicted. L.S.

N67-39402* Massachusetts Inst. of Tech., Cambridge.

LUNAR SOIL ENGINEERING AND ENGINEERING GEOLOGY, JULY 1-31, 1967

T. William Lambe and James K. Mitchell (Calif. Univ., Berkeley) 20 Oct. 1967 18 p Presented at the Conf. on Lunar Exploration and Sci., Santa Cruz, Calif., 31 Jul.-13 Aug. 1967

(Grants NSG-496; NSR-05-003-189)

(NASA-CR-61178) CFSTI: HC \$3.00/MF \$0.65 CSCL 22A

The recommendations for the development of a long-range program in soil and rock engineering for support of lunar exploration and science are presented. The goals are identified as being the prediction and quantitative determination of soil and rock properties, development of analytical techniques, and the utilization of lunar environmental conditions for the understanding of terrestrial soil and rock behavior. The problems are listed, and the engineering program is outlined. Tabulated data are given on soil and rock properties, methods for measuring the properties, and test methods for acquisition of data for property evaluation. N.E.N.

N67-40163* Lincoln Lab., Mass. Inst. of Tech., Lexington.
RADAR STUDIES OF THE MOON, VOLUME I Final Report
 19 Oct. 1967 29 p refs
 (Contract NSR-22-009-106)
 (NASA-CR-89585) CFSTI: HC\$3.00/MF\$0.65 CSCL 03A

Observation of the mean properties of the lunar surface and their interpretations are considered. Radar cross sections were measured at 23 cm with high precision. Echo power versus delay measurements were made at 3.8 cm and 23 cm, and discussions are given on the polarized, depolarized and linearly polarized components. The ratio of the two principal backscattering coefficients for linearly polarized waves were also measured at both 3.8 and 23 cm. Radiometric observations of the polarization of the thermal emission across the lunar disk are described. Data indicate the lunar surface is gently undulating and is characterized by a mean slope of less than 10° . The uppermost surface layers have a relative dielectric constant not more than and probably less than 2.6. The polarization data were explained on the basis of scattering from rocks or pebbles. The backscattering at oblique angles of incidence appears to be direct measure of the surface density.
 N.E.N.

N67-40434* Boeing Co., Seattle, Wash.
LUNAR ORBITER IV POSTMISSION PHOTO SUPPORTING DATA
 21 Sep. 1967 465 p
 (Contract NAS1-3800)
 (NASA-CR-66472) CSCL 02C

A brief discussion of the general concepts and methods employed to derive the photo supporting data and other parameters for the mission IV photos are presented in the two main sections of this document. The supporting data information section defines the parameters contained in the photo evaluation computer program (EVAL), the version of the ephemeris data used, and summarizes the sources of input data required for computation of the photographic supporting data. The supporting and evaluation data section includes the input data not duplicated within other documents. Also included are the output listings of the EVAL computer program for each photo.
 Author

A67-19332

IAA ABSTRACTS

A67-18376

CRATER DIAMETER-DEPTH RELATIONSHIP FROM RANGER LUNAR PHOTOGRAPHS.

Jiří Bouška (Karlova Universita, Astronomický Ústav, Prague, Czechoslovakia).

Nature, vol. 213, Jan. 14, 1967, p. 166.

Criticism of Baldwin's investigation of the relationship between diameter and depths for some lunar craters from Ranger 7 photographs. Baldwin found that the diameter-depth relationship for these craters may be represented by the equation $D = 0.0256 d^2 + d + 0.6300$, where D and d are the logarithmic diameter and depth of craters in feet. The author measured the cross sections of some primary craters from the Ranger 7, 8, and 9 photographs and points out that the crater diameter-depth relationship may be represented by the equation $D = 0.96 d + 0.98$, where D and d are the logarithmic diameter and depth of craters in meters. M. F.

A67-18428

AN INTRODUCTION TO THE STUDY OF THE MOON.

Zdeněk Kopal (Manchester, University, Dept. of Astronomy, Manchester, England).

Dordrecht, D. Reidel Publishing Co.; New York, Gordon and Breach Science Publishers, Inc. (Astrophysics and Space Science Library, Volume 4), 1966. 464 p. \$27.50.

This text is designed to provide an introduction to the study of the moon, based on a broad background of astronomy, physics, and chemistry. The emphasis throughout is on the development of basic methods from first principles rather than on a mere enumeration of facts. A survey of present knowledge of the moon and of the dynamics of the earth-moon system, obtained mainly from astronomical methods, is given. The internal lunar structure is examined. The surface features are interpreted, keeping in mind that the surface of the moon must be regarded as a "boundary condition" of all the internal processes discussed as well as an "impact counter" of all external collisions which have disfigured the face since its origin. The radiation from the moon in all domains of the spectrum and its bearing on the microstructure of the lunar surface on a scale much smaller than that resolvable by telescopic means, not only from the earth but also from orbiting spacecraft, is discussed. S. Z.

A67-18648

MARTIAN AND LUNAR CRATERS.

R. A. Wells and G. Fielder (London, University, Observatory, Mill Hill, Middx., England).

Science, vol. 155, Jan. 20, 1967, p. 354-356. 30 refs.

Comment on a recent paper by Öpik, in which he cited a note by Fielder and states that attempts to ascribe a volcanic origin to Martian features can be "ignored completely." Fielder's article on Martian volcanism is based on the argument that many years of study have shown that the moon is partly volcanic; the ring structures, craters, and lineaments of Mars are remarkably like those of the moon, therefore Mars has probably been shaped partly by volcanic forces. A reply by Öpik is included. B. B.

A67-19003

CONTINENTAL-OCEANIC BOUNDARIES OF EARTH AND THEIR RELEVANCE TO TECTONIC SPECULATIONS ABOUT THE MOON AND THE PLANETS.

James W. Skehan (Boston College, Geology Dept. and Geology-Astrogeology Research Center, Chestnut Hill, Mass.).

(*New York Academy of Sciences, Conference on Planetology and Space Mission Planning*, New York, N.Y., Nov. 3, 4, 1965, Paper.) *New York Academy of Sciences, Annals*, vol. 140, Dec. 16, 1966, p. 107-113. 25 refs.

Examination of considerations relating to the formation of linear fold mountains along continental margins on the earth, including speculations about why such features are absent on the moon and Mars. It is thought that there may be an indirect relationship between the development or absence of fold mountains and the presence or absence of a magnetic field. Such a relationship may shed light on the nature of other processes and especially on the role played by radiogenic heat. Proposals by Birch (1965) and Elsasser (1958) are noted. D. H.

A67-19004

STRUCTURE OF THE LUNAR LITHOSPHERE.

Ferdinand A. deWiess (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).

(*New York Academy of Sciences, Conference on Planetology and Space Mission Planning*, New York, N.Y., Nov. 3, 4, 1965, Paper.) *New York Academy of Sciences, Annals*, vol. 140, Dec. 16, 1966, p. 114-128. 22 refs.

Review of findings regarding the structure of the lunar lithosphere, using data obtained by ground-based telescopes and Rangers 7, 8, and 9. The 17,700 photographs taken during the three Ranger missions reveal a smoothness of lunar terrain features that is in agreement with concepts of surface properties based on interpretation of data obtained from radar, infrared, microwave, photometric, and polarimetric observations of the moon. Photographs obtained by Soviet and U.S. soft-landers are included. D. H.

A67-19037

MANNED EXPLORATION OF THE LUNAR SURFACE.

Donald P. Elston and Spence R. Titley (U.S. Geological Survey; Arizona, University, Tucson, Ariz.).

(*New York Academy of Sciences, Conference on Planetology and Space Mission Planning*, New York, N.Y., Nov. 3, 4, 1965, Paper.) *New York Academy of Sciences, Annals*, vol. 140, Dec. 16, 1966, p. 636-646. 10 refs.

Survey of a projected 10-year exploration program for the lunar surface, including the examination of problems fundamental to the origin, evolution, and geological history of the moon. Engineering concepts for surface exploration are considered, and exploration objectives are outlined. M. F.

A67-19332

THE MOON AND THE PLANET MARS.

Gerard P. Kuiper (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).

IN: ADVANCES IN EARTH SCIENCE; INTERNATIONAL CONFERENCE ON THE EARTH SCIENCES, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS., SEPTEMBER 30-OCTOBER 2, 1964, CONTRIBUTIONS.

Edited by P. M. Hurley. Cambridge, Mass., M.I.T. Press, 1966, p. 21-70. 37 refs.

Review of the principal features of the moon and Mars, pointing out that the primary distinguishing parameter among the planets is their mass, the distance from the sun being of lesser importance. The masses of the moon and Mars are respectively about 1/80 and 1/10 the mass of the earth. Four hypotheses are reviewed that have been advanced to account for the existence and general appearance of the lunar maria; such maria are low-level areas flooded by lunar lavas. Findings based on photographs obtained with ground-based telescopes and cameras on Rangers 7, 8, and 9 as well as aerial photographs of terrestrial lava flows are described. Although most existing (ground-based) photographic coverage of Mars is limited to a 2% to 3% resolution (features 2% to 3% of a Mars diameter can be distinguished), a number of facts that are known or inferred on good grounds are summarized. D. H.

A67-19429

A67-19429

ON SOFT LANDING OF MANNED SPACE VEHICLE ON LUNAR SURFACE.

J. M. J. Kooy.

Ruimtevaart, vol. 15, Dec. 1966, p. 152-157.

Calculation of the hover maneuver required of a manned space vehicle in order for it to achieve a soft landing on the lunar surface. A determination is made of the rate of fuel consumption required for the vehicle to descend to a small altitude above the lunar surface and to hover at this altitude above a suitable landing site. A. B. K.

A67-19659

VOLCANIC RINGS ON THE MOON.

G. Fielder (London, University, Observatory, Mill Hill, Middx., England).

Nature, vol. 213, Jan. 28, 1967, p. 333-336.

Interpretation of revealing details on recent Orbiter 1 photographs of the Flamsteed P ring structure and Surveyor 1 photographs of the upper part of the mountain Flamsteed θ on the moon. It is concluded that the ringwall of Flamsteed P is a youthful volcanic feature, and that the slopes of dome shaped hills preserve concentric ridging characteristic of flow ridging. These results are said to negate the long-held hypothesis that all low "elementary rings" on the moon are old worn-down impact craters. B. B.

A67-19854

LINEAR POLARIZATION OF THE MOON AT 6, 11, AND 21 CM WAVELENGTHS.

R. D. Davies and F. F. Gardner (Commonwealth Scientific and Industrial Research Organization, Div. of Radiophysics, Chippendale New South Wales, Australia).

Australian Journal of Physics, vol. 19, Dec. 1966, p. 823-836.

17 refs.

The 210-ft radio telescope at Parkes provides adequate resolution at wavelengths of 6, 11, and 21 cm for the derivation of the distribution of linear polarization across the disk of the moon. The polarization observations indicate an increase in dielectric constant with increasing wavelength. The observed brightness distributions at all wavelengths indicate a rough surface. A roughness corresponding to a mean tilt of surface normals of about 12° is consistent with both the brightness and polarization distributions, and also with 68-cm radar observations, which sample a similar depth of lunar material. The dielectric constant of the rough surface model at 6- and 11-cm wavelengths is significantly less than that deduced from the radar data. The discrepancy may be removed in a model where the surface layer is composed of a mixture of materials of different dielectric constants. For example, a mixture of 65% $\epsilon \approx 1.6$ and 35% $\epsilon \approx 5.0$ would give the observed polarization characteristics at 11 cm and the radar reflectivity at 68 cm. (Author)

A67-19990

LUNAR SURFACE ACCESSIBILITY FOR MANNED MISSIONS, 1968-1988.

William D. Kinney, James O. Cappellari, Jr., and James S. Dudek (Bellcomm, Inc., Trajectory Analysis Dept., Washington, D.C.). American Astronautical Society, Space Flight Mechanics Specialist Conference, University of Denver, Denver, Colo., July 6-8, 1966, Paper 66-131, 12 p.

The results of a lunar surface accessibility study are presented for manned lunar orbit rendezvous missions. The time span considered extends from 1968 to 1988 and includes a complete lunar cycle of 18.6 years. The results show that when the translunar trajectories are limited to the "free return" class, the area on the lunar surface which is accessible "every day of the month" is relatively small and exhibits a significant cyclic variation (with a minimum in 1968 and a maximum in 1975) having an 18.6 year period. These results contrast with those obtained using more general translunar trajectories in which the accessible region is quite large and does not exhibit any significant variation. (Author)

A67-20021 *

LUNAR RECEIVING LABORATORY.

James C. McLane, Jr., Elbert A. King, Jr., Donald A. Flory, Keith A. Richardson, James P. Dawson (NASA, Manned Spacecraft Center, Lunar Receiving Laboratory Program Office, Facility Requirements Office, Houston, Tex.), Walter W. Kemmerer, and Bennie C. Wooley (NASA, Manned Spacecraft Center, Medical Research and Operations Directorate, Biomedical Specialties Branch, Houston, Tex.).

Science, vol. 155, Feb. 3, 1967, p. 525-529.

Discussion of the different functions which the Lunar Receiving Laboratory will perform. These functions include: (1) distribution of lunar samples to the scientific community for detailed investigations after a period of biologic quarantine; (2) performance of scientific investigations of samples that are time-critical and must be accomplished within the quarantine period; (3) permanent storage under vacuum of a portion of each sample; and (4) quarantining and testing of the lunar samples, spacecraft, and astronauts for unlikely, but potentially harmful, back-contamination (contamination of extra-terrestrial origin). M. F.

A67-20661 *

LUNAR AIMP PHOTOGRAPHIC DATA PROCESSING SYSTEM.

James S. Albus (NASA, Greenbelt, Md.), Rex D. Depew, John E. Gaffney, Jr., and James H. Ricard (International Business Machines Corp., Gaithersburg, Md.).

(Institute of Electrical and Electronics Engineers, Aerospace and Electronic Systems Convention, Washington, D.C., Oct. 3-5, 1966, Paper.)

IEEE Transactions on Aerospace and Electronic Systems, Supplement, vol. AES-2, Nov. 1966, p. 114-118.

Description of a data processing system that transforms photographic scans of the moon into rectified lunar pictures. The system was developed under the Lunar AIMP (Anchored Interplanetary Monitoring Platform) satellite program of NASA's Goddard Space Flight Center. Three coplanar narrow-beam optical sensors mounted on the spinning satellite provide the photographic input. The satellite's processor selects lunar image data for transmission, delta-modulates these data, and interleaves them with necessary navigational parameters. The ground processor reconstitutes the delta-modulated image data into lunar pictures arranged so as to give the appearance of being the projection of the lunar surface onto one of 24 projection planes. This conversion is performed by locating each lunar element corresponding to an item of image data followed by selecting the projection plane either as input or by the program. The lunar elements are then mathematically projected onto the plane, and the projection is "formatted" onto a magnetic tape from which the output picture is generated. V. Z.

A67-20675 *

LUNAR SURFACE NAVIGATION.

Thomas T. Trexler and Robert B. Odden (Bendix Corp., Bendix Systems Div., Ann Arbor, Mich.).

(Institute of Electrical and Electronics Engineers, Aerospace and Electronic Systems Convention, Washington, D.C., Oct. 3-5, 1966, Paper.)

IEEE Transactions on Aerospace and Electronic Systems, Supplement, vol. AES-2, Nov. 1966, p. 252-259.

Contract No. NAS 8-11292.

Analysis of three generalized lunar surface navigation concepts, subject to the lunar environmental constraints. These hybrid concepts consist of both position fix and dead reckoning subconcepts and are based on a passive nongyro, and inertial, and rf system. A generalized error model of the lunar surface navigation function is applied to assess navigation system accuracy for each of the three systems. The analytical approach to model derivation is essentially a covariance technique where 3σ error measures of lunar physical uncertainties are related to a 3σ vehicle position error ellipsoid about a true point on the lunar surface. The error model digital computer program is applied to the navigation concepts. The results are given which indicate representative component and total concept accuracy requirements for lunar surface navigation in the 1972 to 1985 era. V. Z.

A67-20841**MEASUREMENT OF THE INTENSITY OF THE PENETRATING RADIATION AT THE SURFACE OF THE MOON.**

S. N. Vernov, P. V. Vakulov, E. V. Gorchakov, Iu. I. Logachev, G. P. Liubimov, A. G. Nikolaev, and N. V. Pereslegina (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR).

(Akademiia Nauk SSSR, Doklady, vol. 169, Aug. 11, 1966, p. 1044-1047.)

Soviet Physics - Doklady, vol. 11, Feb. 1967, p. 706-708. Translation.

4

A67-20932**A CRITIQUE OF METHODS FOR ANALYSIS OF THE DIAMETER-FREQUENCY RELATION FOR CRATERS WITH SPECIAL APPLICATION TO THE MOON.**

C. R. Chapman and R. R. Haefner (Smithsonian Institution, Smithsonian Astrophysical Observatory, Cambridge, Mass.).
Journal of Geophysical Research, vol. 72, Jan. 15, 1967, p. 549-557. 25 refs.

The incremental and cumulative methods of analyzing data on the diameter-frequency relationship for craters are contrasted. The traditional cumulative method is found to lead to serious inconsistencies for two basic reasons: (1) the diameter-frequency relation of the form $N = AD^B$ (N the number of craters per square kilometer per kilometer diameter increment, D the diameter in kilometers) is not expected to, and does not in reality, have a constant B; B varies with diameter in a manner to which the cumulative frequency distribution is insensitive; (2) cumulative crater counts do not form a normal distribution of independent points and therefore cannot be fitted by straightforward least-squares methods without leading to spurious values of B because of the propagated error. A much improved least-squares method is developed to determine the incremental frequency distribution. The method includes proper weighting and the proper determination of the average diameter of craters in a given diameter increment. When crater counts subject to observational incompleteness are properly excluded from the fitting, a computer program based on the above least-squares methods yields consistent results for the highlands and for the maria from various independent sets of crater data. It is found that there is a continuing variation with diameter in the value of B (varying from about -4.3 to -2.0 for maria craters and from about -2.2 to -2.9 for highland craters), which makes it imperative that the diameter range be defined when discussing frequency relations and which makes extrapolations into unobserved diameter ranges very questionable. (Author)

A67-20934 ***STUDIES OF THE MIDDLE- AND FAR-INFRARED SPECTRA OF MINERAL SURFACES FOR APPLICATION IN REMOTE COMPOSITIONAL MAPPING OF THE MOON AND PLANETS.**

James R. Aronson, Alfred G. Emslie, Ronald V. Allen, and Hugh G. McLinden (Arthur D. Little, Inc., Cambridge, Mass.).
Journal of Geophysical Research, vol. 72, Jan. 15, 1967, p. 687-703. 22 refs.

Contracts No. NAS 8-2537; No. NAS 8-20122.

The middle- and far IR spectra of silicate minerals were investigated, theoretically and experimentally, for use in remote sensing of the composition of lunar or planetary surfaces. The large amount of characteristic information in the spectral region 15-200 μ is very useful for identifying minerals in remote-sensing applications. Further, the information is necessarily present even if the mineral surface is rough or particulate. The ways in which the spectra of composite samples may be understood in terms of their components have been investigated. The result has been the development of distinct mixing rules, depending on whether the individual particles are larger or smaller than the wavelength of the radiation. Finally, a brief description of the instrumental considerations that would be involved in using these results on a space mission is given, showing the feasibility of remote compositional sensing. (Author)

A67-20935**RAPID REMOTE SENSING BY SPECTRUM MATCHING TECHNIQUE. II.**

Graham R. Hunt, John W. Salisbury, and John W. Reed (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Bedford, Mass.).

Journal of Geophysical Research, vol. 72, Jan. 15, 1967, p. 705-719. 7 refs.

Spectrum-matching technique for rapid remote compositional sensing based on the instrumental comparison, over a selected wavelength interval, of the mid-IR emission spectrum from the target with the reflection spectra of a series of polished plates of known composition, which are included as an integral part of the instrument. It is primarily useful when the remote sensing is carried out on a low energy target in the presence of a time variable intervening attenuator. To acquire meaningful data under these conditions, a premium is placed on rapidity of measurement. The feasibility of the technique (described in an earlier paper) is demonstrated in the laboratory using two instruments - one a simple single spot measuring device and the other a more sophisticated x-y scanning instrument. The 8- to 14- μ daytime lunar emission was examined using the simpler of these two instruments, and small but consistent differences in emission have been delineated between different areas on the lunar surface, which indicate that either compositional and/or particle-size differences exist. (Author)

A67-20939 ***LUNAR SURFACE EXPLORATION BY SURVEYOR SPACECRAFT - INTRODUCTION.**

Leonard D. Jaffe (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

Journal of Geophysical Research, vol. 72, Jan. 15, 1967, p. 773-778. 6 refs.

NASA-sponsored research.

The Surveyor 1 spacecraft, its operation, and findings are briefly described. Data were obtained on the topography, photometric and colorimetric properties, temperature, radar cross section, and mechanical properties of the lunar surface. The mare surface around the landing site consists of separate, somewhat cohesive, particles. The bulk of the particles are smaller than 1 mm (0.04 in.), but the particle size distribution extends up to 1-m blocks or larger. The surface bearing resistance is about 5×10^5 dynes/cm² (7 psi). The solar corona was photographed from the moon. Plans for future Surveyor flights are outlined. (Author)

A67-20940 ***LUNAR SURFACE THERMAL CHARACTERISTICS FROM SURVEYOR 1.**

John W. Lucas, James E. Conel, William A. Hagemeyer (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.), Robert R. Garipay (Hughes Aircraft Co., El Segundo Div., Los Angeles, Calif.), and John M. Saari (Boeing Co., Scientific Research Laboratories, Seattle, Wash.).

Journal of Geophysical Research, vol. 72, Jan. 15, 1967, p. 779-789. 6 refs.

Evaluation of in situ thermal engineering data from Surveyor 1. It is indicated that the local lunar surface is highly insulating - as was predicted from earth-based observations. The effects of non-Lambertian surface thermal emission, a feature of lunar IR behavior also observed from earth, were apparently sensed. There is no evidence of a dust thermal blanket on Surveyor 1. B.B.

A67-20941 ***LUNAR SURFACE SURVEYOR RADAR RESPONSE.**

W. E. Brown, Jr. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

Journal of Geophysical Research, vol. 72, Jan. 15, 1967, p. 791-799.

The Surveyor 1 used two radar systems during the touchdown sequence. The signal data have been subjected to a complex computational reduction procedure to determine some of the lunar surface microwave characteristics. Normalized values for a radar cross section have been determined for normal incidence and 25° off-normal backscatter. The off-normal beams apparently traversed

A67-20942

crater-like surface characteristics. A probable Surveyor landing site has been located by means of the radar information in conjunction with Lunar Orbiter and Surveyor photographs. (Author)

A67-20942 *

LUNAR SURFACE MECHANICAL PROPERTIES - SURVEYOR 1. Elmer M. Christensen, Claude E. Chandler, Frank B. Sperling (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.), S. A. Batterson (NASA, Langley Research Center, Dynamic Loads Div., Hampton, Va.), H. E. Benson (NASA, Manned Spacecraft Center, Houston, Tex.), R. H. Jones (Hughes Aircraft Co., El Segundo, Calif.), Ronald F. Scott (California Institute of Technology, Pasadena, Calif.), E. N. Shipley (Bellcomm, Inc., Washington, D.C.), and G. H. Sutton (Hawaii, University, Hawaii Institute of Geophysics, Honolulu, Hawaii). Journal of Geophysical Research, vol. 72, Jan. 15, 1967, p. 801-813.

Engineering telemetry data and lunar surface photographs by Surveyor 1 have been evaluated for information on the mechanical properties of the lunar surface material at the Surveyor 1 landing site. Based primarily on photographic evidence, estimates of soil density, cohesion, and other soil characteristics are presented. Also, the mechanisms in which the lunar material is believed to have failed under the footpad impacts are discussed. Because dynamic soil reactions cannot be interpreted directly from the available data, a comparative study using computer-simulated landings was initiated. Preliminary results of this study, still in progress, are presented. (Author)

A67-20944 *

OBSERVATIONS OF DUST PARTICLES ON SURVEYOR 1. William A. Hagemeyer (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). Journal of Geophysical Research, vol. 72, Jan. 15, 1967, p. 819-825.

Brief account of the examination of TV pictures of Surveyor 1 compartment radiators, taken on June 11 and July 12, 1966. The cause of some changes in apparent dust locations on the top of two radiators, revealed by matching pictures taken on different dates, is discussed. For an interpretation of these lunar photographic results, pictures were taken under reconstructed identical laboratory conditions with various particles sprinkled on the top of identical radiators. Common sand particles of 0.075 to 2.5 mm were found to produce a photographic effect similar to that seen on lunar TV pictures. V. Z.

A67-20945 *

SOIL MECHANICS SURFACE SAMPLER EXPERIMENT FOR SURVEYOR. Ronald F. Scott (California Institute of Technology, Div. of Engineering and Applied Science, Pasadena, Calif.). Journal of Geophysical Research, vol. 72, Jan. 15, 1967, p. 827-830. Contract No. JPL-CIT 69811.

Description of a lunar surface sampling device to be added to the payload of the Surveyor lunar probe. The device includes a mechanism capable of extending, contracting, swinging right and left azimuthally, and moving vertically in both directions. The operations performable by the device include a static vertical bearing or penetration test, a static drag or horizontal load test, an impact deceleration test, a weighing experiment, and - with other equipment - an α -scattering experiment. The mode of operation of the device is discussed. V. Z.

A67-20946 *

CHEMICAL ANALYSIS EXPERIMENT FOR THE SURVEYOR LUNAR MISSION. Anthony L. Turkevich, Karlfried Knolle (Chicago, University, Enrico Fermi Institute for Nuclear Studies and Dept. of Chemistry, Chicago, Ill.), Ernest Franzgrote (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.), and James H. Patterson (Argonne National Laboratory, Chemistry Div., Argonne, Ill.). Journal of Geophysical Research, vol. 72, Jan. 15, 1967, p. 831-839. 5 refs. AEC-sponsored research; Grant No. NSG-127-61; Contracts No. JPL-950315; No. JPL-950750.

Experiment designed to determine the chemical composition of the lunar surface on the Surveyor soft-landing science missions to the moon. The instrument utilizes the characteristic spectrums of backward-scattered α particles and protons from (α , p) reactions to establish the elements present in a sample. The instrument can determine the amounts of most elements present in rocks with a sensitivity and accuracy of about 1 at. %. Satisfactory analyses of a variety of terrestrial samples have been obtained. (Author)

A67-20957

ORBITER OBSERVATIONS OF THE LUNAR SURFACE. L. C. Rowan (U.S. Geological Survey, Flagstaff, Ariz.). American Astronautical Society, Symposium on the Physics of the Moon, Washington, D.C., Dec. 29, 1966, Paper AAS 66-180. 42 p. 7 refs.

Study of Lunar Orbiter photographs which shows that the lunar surface seems to have been formed by complexly related impact, volcanic, tectonic, and mass wasting processes. The most important observation is thought to be the great significance of mass wasting as an erosional and depositional process in both the maria and terra. Facies of the rim material of the crater Dionysius demonstrate the outward progression from depositional to erosional impact processes. Volcanic activity is widely manifested as individual features as well as large, complex provinces. Mass movement is thought to have significantly reduced the depth-to-diameter ratio of large craters. B.B.

A67-20958

CRATER STATISTICS AND EROSION. R. J. Collins (Minnesota, University, Minneapolis, Minn.) and B. G. Smith (Bellcomm, Inc., Washington, D.C.). American Astronautical Society, Symposium on the Physics of the Moon, Washington, D.C., Dec. 29, 1966, Paper AAS 66-183. 34 p. 33 refs.

Review of the essential features of lunar cratering statistics and their interpretation in terms of the meteoroid impact hypothesis. The crater size distribution function is introduced. A simple model is used to discuss the concept of crater lifetime and the mechanisms for its limitation, with relevance to the existence of saturated surfaces and equilibrium distribution functions. Secondary cratering and its importance are considered. It is pointed out that several different theoretical models adequately match the measured distributions and that this argues against the exclusive justification of any one model. The conclusion is drawn that a nonequilibrium distribution function should contain information about the crater production process, but that an equilibrium distribution may be sensitive primarily to local surface properties. (Author)

A67-20959

REVIEW OF LUNAR INFRARED OBSERVATIONS. J. M. Saari and R. W. Shorthill (Boeing Co., Scientific Research Laboratories, Seattle, Wash.). American Astronautical Society, Symposium on the Physics of the Moon, Washington, D.C., Dec. 29, 1966, Paper AAS 66-184. 44 p. 30 refs.

Study of such anomalies on the moon's surface as ray craters which cool more slowly than their environs during an eclipse and "hot spots" which are present during a total eclipse. These anomalies are identified with a variety of geological features, and the current status of the thermophysical and geological interpretations of these discoveries is discussed. B.B.

A67-20960 *

OPTICAL PROPERTIES AND INFRARED EMISSION OF THE MOON. J. J. Hopfield (Princeton University, Dept. of Physics, Princeton, N.J.). American Astronautical Society, Symposium on the Physics of the Moon, Washington, D.C., Dec. 29, 1966, Paper AAS 66-185. 24 p. 33 refs. Contract No. NSR-24-005-047.

Outline of the information known from optical and thermal studies about the physical properties apparently common to most of the lunar surface. Optical photometric properties, optical polarization, IR emission, and thermal radio emission are discussed. In each case a description is given of the available data and of the simplest models of the physics of the lunar surface which can lead to such observations. Emphasis is on understanding the physics of the zero-order models, rather than the refinement of models to include higher-order effects. B.B.

A67-20962

THE GEOMETRIC AND DYNAMICAL FIGURES OF THE MOON.

W. Kaula (California, University, Institute of Geophysics and Planetary Physics, Los Angeles, Calif.).

American Astronautical Society, Symposium on the Physics of the Moon, Washington, D.C., Dec. 29, 1966, Paper AAS 66-189. 8 p. 9 refs.

Investigation of the external gravitational field, the topographic surface, and the moments of inertia of the moon. Orbital perturbations of either a natural or artificial body are used at present to measure the gravitational field. Photographs made from the earth are used to measure the topographic surface. The moon's response to the earth's torque is shown by the inclination of the lunar equator to the earth-moon orbit, and by the amplitude of the physical librations, observed by either heliometer or photography. B.B.

A67-21000

GLOBAL SYSTEM OF COORDINATES AND DENOMINATIONS ON THE MOON [GLOBAL'NAIA SISTEMA KOORDINAT I NAIMENOVANII NA LUNE].

Iu. N. Lipskii.

Akademiia Nauk SSSR, Vestnik, vol. 37, Jan. 1967, p. 18-20. In Russian.

Application of lunar photographs obtained by the probes "Luna 3" and "Zond 3" to the creation of a system of selenographic coordinates enveloping both the near and far sides of the moon. The names given to 18 marked points on the far side are indicated. V.P.

A67-21011

THE SHAPE OF THE MOON, ITS INTERNAL STRUCTURE AND MOMENTS OF INERTIA.

Z. Kopal (Manchester, University, Dept. of Astronomy, Manchester, England).

(Discussion on the Physics of the Moon and Its Environment, London, England, June 3, 4, 1965, Paper.)

Royal Society (London), Proceedings, Series A, vol. 296, Feb. 7, 1967, p. 254-265. 40 refs.

Survey of the factors and processes relating the observed form of the lunar surface to the internal structure and moments of inertia of the moon. It is found by harmonic analysis of the moon's shape that the surface of the moon is not only not a spheroid or ellipsoid, but contains many significant harmonic terms, the largest of which are of fourth order. The sum of these terms makes the moon deviate from a mean sphere by ± 2 km over extensive regions, local differences attaining 8 to 9 km in elevation having been noted on the limb. It is concluded that the lunar globe must possess sufficient strength to sustain stress differences of the order of 10^9 dynes/cm². The moments of inertia about the principal axes of inertia of the lunar globe, as determined from the moon's physical librations, are found to be seriously at variance with a state of hydrostatic equilibrium of a homogeneous body. It is believed that they can be accounted for only by assuming an asymmetric inhomogeneity of the lunar globe. A.B.K.

A67-21012

THERMAL EFFECTS ON THE FIGURE OF THE MOON.

B. J. Levin (Akademiia Nauk SSSR, Institut Fiziki Zemli, Moscow, USSR).

(Discussion on the Physics of the Moon and Its Environment, London, England, June 3, 4, 1965, Paper.)

Royal Society (London), Proceedings, Series A, vol. 296, Feb. 7, 1967, p. 266-269. 24 refs.

Discussion of the nature and cause of the deviation of the lunar figure from the equilibrium one. It is proposed that the ablateness of the moon is due to thermal effects associated with a decrease in the mean surface temperature, or the constant subsurface temperature of the lunar soil, from the equator toward the poles. A misinterpretation of certain previous findings by the author concerning the thermal expansion of the equatorial zone is clarified. A.B.K.

A67-21013 *

CONVECTION IN THE MOON AND THE EXISTENCE OF A LUNAR CORE.

S. K. Runcorn (Newcastle-upon-Tyne, University, School of Physics, Dept. of Geophysics and Planetary Physics, Newcastle-upon-Tyne, England; California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

(Discussion on the Physics of the Moon and Its Environment, London, England, June 3, 4, 1965, Paper.)

Royal Society (London), Proceedings, Series A, vol. 296, Feb. 7, 1967, p. 270-284. 27 refs.

Analysis of the discrepancy between the observed values of the moon's principal moments of inertia and its surface ellipticity and the values which should obtain if the moon were in a state of hydrostatic equilibrium. Since the ellipticity of the earthward bulge, determined statistically from the geometrical librations, is over twice that determined dynamically from Cassini's laws, it is concluded that the internal density varies with angle. It is suggested that this may arise through convection or because the moon has a finite strength which enables original density anomalies to be retained. However, the latter explanation is regarded as untenable if creep rates in the interior exceed 10^{-20} sec⁻¹. It is believed that a search for evidence of small movements in the surface would be fruitful. It is stressed that a satisfactory theory must explain why the mechanical ellipticity is neither $1/4$ nor 1 . A.B.K.

A67-21016

EVIDENCE FROM THE SURFACE CONFIGURATION OF THE MOON ON ITS DYNAMICAL EVOLUTION.

G. J. F. MacDonald (California, University, Institute of Geophysics and Planetary Physics, Los Angeles, Calif.).

(Discussion on the Physics of the Moon and Its Environment, London, England, June 3, 4, 1965, Paper.)

Royal Society (London), Proceedings, Series A, vol. 296, Feb. 7, 1967, p. 298-303.

Study of the relation between observed distortions of lunar craters and the past shape of the moon. The limitations imposed by the present surface structure on the past dynamical history of the moon are examined. Calculations bearing on the dynamical evolution of the earth-moon system are reviewed briefly, as well as the implications these calculations have on the past shape of the lunar surface. It is concluded that at the time of close approach to the earth the moon was either not within about 5 earth radii of the earth or else the craters date from a time which is recent compared with the time of close approach. A.B.K.

A67-21017

THE METEORITIC ENVIRONMENT OF THE MOON.

F. L. Whipple (Smithsonian Institution, Smithsonian Astrophysical Observatory; Harvard University, Harvard College Observatory, Cambridge, Mass.).

(Discussion on the Physics of the Moon and Its Environment, London, England, June 3, 4, 1965, Paper.)

Royal Society (London), Proceedings, Series A, vol. 296, Feb. 7, 1967, p. 304-315. 40 refs.

Diverse evidence concerning the probable particulate influx on the moon is assembled along with estimates of the rather large uncertainties. The masses under consideration range from 10^{-14} to 10^{-18} g, the total estimated influx amounting to the order of 4×10^{-16} g/cm²-sec. The occurrence of large lunar craters assumed to have accumulated over 4×10^9 years appears consistent with the expected production rate by Apollo-type asteroids. Cometary nuclei may or may not have contributed significantly. There is possibly a dearth

A67-21018

of smaller craters of diameter less than 50 m as compared to the probable production by meteoritic influx. The overturn of lunar material by cratering impacts may have largely blanketed craters with diameters smaller than 3 to 30 m. (Author)

A67-21018

OBSERVATIONAL EVIDENCE OF THE METEORITIC BOMBARDMENT.

R. C. Jennison (Manchester, University, Physical Laboratories, Manchester, England).

(Discussion on the Physics of the Moon and Its Environment, London, England, June 3, 4, 1965, Paper.)

Royal Society (London), Proceedings, Series A, vol. 296, Feb. 7, 1967, p. 316-319.

Prima facie evidence for the meteoritic bombardment of the moon is given by the known meteoritic environment of the earth's atmosphere. The impact by particles of different sizes and the likely damage to the lunar surface are discussed, reference being made to terrestrial craters and experiments with hypervelocity projectiles. An attempt is made to reconcile the formation and distribution of certain features with the results of meteoritic bombardment. In a number of instances the reconciliation is unsatisfactory and it is likely that the cause may be internal. It is pointed out that once a surface layer of dust has been formed, the effect of subsequent impacts by the smaller particles will only very slowly increase the depth. (Author)

A67-21023

MEASUREMENTS OF LUNAR RADIO BRIGHTNESS DISTRIBUTION AND CERTAIN PROPERTIES OF ITS SURFACE LAYER.

A. E. Salomonovich (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Discussion on the Physics of the Moon and Its Environment, London, England, June 3, 4, 1965, Paper.)

Royal Society (London), Proceedings, Series A, vol. 296, Feb. 7, 1967, p. 354-365. 18 refs.

Measurement of the distribution of lunar radio brightness at the wavelengths of 4 mm, 8 mm, 2 cm, and 3.2 cm. The law of decrease in the effective surface temperature from the equator to the poles is determined, as well as the average effective dielectric constant, and the phase dependence of the brightness temperature in the center of the lunar disk. A description is given of a method of relative measurements developed for the detection of brightness temperature distinctions ("radio contrasts") between "sea" and "continental" regions on the moon, using the new known averaged data characteristics of lunar radio emission. On the basis of comparative measurements carried out in the 4- and 8-mm wavelength ranges relatively small contrasts are noted between the brightness temperatures of "sea" and "continental" regions. The average excess temperature of the "sea" region during a period of lunation is found to be $1.5 \pm 0.5^\circ$. It is concluded that the difference in night surface temperatures in the regions compared is about 80°K .

A. B. K.

A67-21024

INVESTIGATION OF THE SURFACES OF THE MOON AND PLANETS BY MEANS OF THERMAL RADIATION.

V. S. Troitskii (Gor'kovskii Gosudarstvennyi Universitet, Gorki, USSR).

(Discussion on the Physics of the Moon and Its Environment, London, England, June 3, 4, 1965, Paper.)

Royal Society (London), Proceedings, Series A, vol. 296, Feb. 7, 1967, p. 366-398. 96 refs.

Summary of experimental and theoretical results of investigations of the surfaces of the moon and the planets based on their thermal radiation. The physical bases for studying the material properties and thermal regime of planetary surfaces from the thermal radiation of these surfaces are outlined. Experimental results of IR and radio-wave measurements of the properties of the lunar surface and its temperature regime are considered, and a theoretical interpretation of these results is given in order to obtain information about the parameters of the material of the upper layer. A. B. K.

A67-21025

THE LUNAR SURFACE AND THE U.S. RANGER PROGRAMME.

G. P. Kuiper (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).

(Discussion on the Physics of the Moon and Its Environment, London, England, June 3, 4, 1965, Paper.)

Royal Society (London), Proceedings, Series A, vol. 296, Feb. 7, 1967, p. 399-417. 24 refs.

Survey of findings concerning lunar surface topography obtained with the aid of Ranger rocket photographs. The findings concerning the texture of the lunar maria are summarized, noting the discovery of collapse depressions and the two-layered structure of the mare surface. Classes of surface features in maria, such as ray craters, white mountains, lineaments, mare ridges, domes, and collapse depressions are considered. An estimate is made of the bearing strength of the mare surface. It is believed that the surface structures discussed are all indicators of the lunar maria as igneous deposits. A. B. K.

A67-21026

STUDY OF THE RANGER PICTURES OF THE MOON.

H. C. Urey (California, University, La Jolla, Calif.).

(Discussion on the Physics of the Moon and Its Environment, London, England, June 3, 4, 1965, Paper.)

Royal Society (London), Proceedings, Series A, vol. 296, Feb. 7, 1967, p. 418-431. 12 refs.

AEC-supported research.

Discussion of the Ranger 7, 8, and 9 photographs of the moon's surface. They appear to indicate a considerable amount of erosion and fragmentation of the surface by micro- and macro-meteorite bombardment and to give evidence of slump features. Material of the maria floors, especially that of Alphonsus, seems to consist of fragmented material to considerable depth. Secondaries are a prominent feature of all these photographs; objects of over 1 million tons have apparently been thrown from Tycho to Mare Cognitum, a distance of 1000 km. B. B.

A67-21027

ON THE RELATIVE DEPTHS OF THE MOON'S MOUNTAIN RINGS AND CRATERS IN THE REGION OF MARE NUBIUM.

A. V. Markov (Akademiia Nauk SSSR, Glavnaia Astronomicheskaya Observatoriia, Pulkovo, USSR).

(Discussion on the Physics of the Moon and Its Environment, London, England, June 3, 4, 1965, Paper.)

Royal Society (London), Proceedings, Series A, vol. 296, Feb. 7, 1967, p. 432-434.

Derivation of an equation by Baldwin which represents the interdependence between the diameter and depth of the moon's craters. The formula is checked by application to the smaller craters on photographs of the Mare Nubium region made by Ranger 7. It is concluded that the Baldwin formula represents this interdependence with diameters from 8 to 67,000 m fairly well. B. B.

A67-21079

ULTRAVIOLET INVESTIGATIONS FOR LUNAR MISSIONS.

William R. Hemphill, William A. Fischer (U.S. Geological Survey, Washington, D.C.), and John E. Dornbach (NASA, Washington, D.C.).

IN: POST APOLLO SPACE EXPLORATION; AMERICAN ASTRONAUTICAL SOCIETY, ANNUAL MEETING, 11TH, CHICAGO, ILL., MAY 3-6, 1965, PROCEEDINGS.

Meeting sponsored by the American Astronautical Society and the IIT Research Institute.

Edited by Francis Narin.

Tarzana, Calif., American Astronautical Society (Advances in the Astronautical Sciences, Volume 20, Part I); Sun Valley, Calif., Scholarly Publications Corp., 1966, p. 397-415. 6 refs.

Preliminary field tests of an active UV imaging system have shown that it is possible to produce images of the terrain from distances as great as 75 ft by means of reflected UV at wavelengths longer than 3300 Å. Minerals that luminesce when exposed to UV

have been detected from distances as great as 200 ft. With appropriate design modifications, it may be possible to utilize a similar system in detecting luminescing minerals from greater distances. Also, with a similar system and appropriate auxiliary equipment such as image intensifiers, it may be possible to discriminate between naturally occurring materials on the basis of reflected UV at wavelengths shorter than 3000 Å. In this part of the spectrum image contrast for some rock types may exceed that from visible light. Information from these and related UV spectral-analysis studies may be useful in evaluating data obtained from passive UV systems in lunar orbit as well as from active systems on the lunar surface.

(Author)

A67-21080

RADIO FREQUENCY REFLECTIVITY EXPERIMENTS PROPOSED FOR AES LUNAR ORBITAL FLIGHTS.

A. R. Barringer (Barringer Research, Ltd., Toronto, Canada). IN: POST APOLLO SPACE EXPLORATION; AMERICAN ASTRONAUTICAL SOCIETY, ANNUAL MEETING, 11TH, CHICAGO, ILL., MAY 3-6, 1965, PROCEEDINGS.

Meeting sponsored by the American Astronautical Society and the IIT Research Institute.

Edited by Francis Narin.

Tarzana, Calif., American Astronautical Society (Advances in the Astronautical Sciences. Volume 20. Part I); Sun Valley, Calif., Scholarly Publications Corp., 1966, p. 417-434. 9 refs.

Contract No. AF 19(628)-2998.

Development of a method for penetrating the lunar surface with rf pulses and analyzing the reflected signals to obtain information on layering and discontinuities beneath the surface. The method is based on the use of short chirp type pulses of multioctave bandwidth in conjunction with spectral analysis receiving techniques for classifying the characteristics of the return signals. A penetration depth of at least 10 m is predicted.

V. P.

A67-21085

SCIENTIFIC EXPLORATION OF THE MOON USING A ROVING VEHICLE.

O. Lyle Tiffany, Eugene M. Zaitzeff (Bendix Corp., Detroit, Mich.), and James A. Downey, III (NASA, Marshall Space Flight Center, Huntsville, Ala.).

IN: POST APOLLO SPACE EXPLORATION; AMERICAN ASTRONAUTICAL SOCIETY, ANNUAL MEETING, 11TH, CHICAGO, ILL., MAY 3-6, 1965, PROCEEDINGS.

Meeting sponsored by the American Astronautical Society and the IIT Research Institute.

Edited by Francis Narin.

Tarzana, Calif., American Astronautical Society (Advances in the Astronautical Sciences. Volume 20. Part I); Sun Valley, Calif., Scholarly Publications Corp., 1966, p. 529-543.

Contract No. NASw-1064.

Discussion of the scientific measurements that could be carried out during a traverse of the moon in the Kepler-Encke region. The measurements considered feasible are active seismic refraction shots to determine subsurface structure and magnetic or gravity anomalies and nuclear measurements along the traverse to determine variations in surface density and chemical composition. The implications of these measurements are examined. The possibility of drilling and recovering samples from the lunar surface is considered, together with the possibility of obtaining information on rock density, chemical composition, and presence of water from core hole logging techniques. A 700-lb instrument package, including instrument support equipment, is proposed.

V. P.

A67-21086

RECENT RESULTS OF LUNAR ECLIPSE MEASUREMENTS SHOWING HOT SPOTS.

R. W. Shorthill and J. M. Saari (Boeing Co., Scientific Research Laboratories, Geo-Astrophysics Laboratory, Seattle, Wash.). IN: POST APOLLO SPACE EXPLORATION; AMERICAN ASTRONAUTICAL SOCIETY, ANNUAL MEETING, 11TH, CHICAGO, ILL., MAY 3-6, 1965, PROCEEDINGS.

Meeting sponsored by the American Astronautical Society and the IIT Research Institute.

Edited by Francis Narin.

Tarzana, Calif., American Astronautical Society (Advances in the Astronautical Sciences. Volume 20. Part I); Sun Valley, Calif., Scholarly Publications Corp., 1966, p. 545-556. 5 refs.

Contract No. AF 19(628)-4371.

The lunar disk was scanned in the IR during the total eclipse of Dec. 19, 1964 using a mercury-doped germanium detector. As expected from previous work, the major ray craters cooled less slowly than their environs. In addition, hundreds of "hot spots" were found on the disk which have been identified with craters or "white areas." Certain seas or portions of seas were thermally enhanced over their environs.

(Author)

A67-21156

THE MOON IN THE SPACE AGE [LA LUNE A L'ERE SPATIALE]. Paris, Presses Universitaires de France, 1966. 186 p. In French. \$4.20.

CONTENTS:

PREFACE. Jean Coulomb, p. V.

FOREWORD [AVANT-PROPOS]. Jean Rösche (Observatoire du Pic du Midi, Bagnères-de-Bigorre, Hautes-Pyrénées, France), p. VII-XI.

GENERALITIES [GENERALITES]. Jean Rösche (Observatoire du Pic du Midi, Bagnères-de-Bigorre, Hautes-Pyrénées, France), p. 1-8.

MOTION OF THE MOON AROUND ITS CENTER OF GRAVITY [MOUVEMENT DE LA LUNE AUTOUR DE SON CENTRE DE GRAVITE]. Th. Weimer (Alger, Université, Observatoire Astronomique, Algiers, Algeria), p. 9-33. 10 refs. [See A67-21157 08-30]

PARALLAX OF THE MOON [LA PARALLAXE DE LA LUNE]. J. Kovalevsky (Institut Pasteur, Bureau des Longitudes, Paris, France), p. 35-44. 15 refs. [See A67-21158 08-30]

SELENODESY AND LUNAR TOPOGRAPHY [SELENODESIE ET TOPOGRAPHIE LUNAIRE]. J. Rösche (Observatoire du Pic du Midi, Bagnères-de-Bigorre, Hautes-Pyrénées, France), p. 45-55. [See A67-21159 08-30]

NATURE OF THE LUNAR SOIL [LA NATURE DU SOL LUNAIRE]. A. Dollfus (Paris, Observatoire, Meudon, Seine-et-Oise, France), p. 57-103. [See A67-21160 08-30]

THE INTERIOR OF THE MOON [SUR L'INTERIEUR DE LA LUNE]. G. Jobert (Paris, Université, Paris, France), p. 105-123. 8 refs. [See A67-21161 08-30]

EVOLUTION OF THE EARTH-MOON SYSTEM [EVOLUTION DU SYSTEME TERRE-LUNE]. Jacques Lévy (Paris, Observatoire, Meudon, Seine-et-Oise, France), p. 125-138. [See A67-21162 08-30]

THE GRAVITATIONAL FIELD OF THE MOON [LE CHAMP DE GRAVITATION DE LA LUNE]. J. Kovalevsky (Institut Pasteur, Paris, France), p. 139-162. [See A67-21163 08-30]

PERTURBATIONS OF A LUNAR SATELLITE DUE TO LONGITUDE TERMS [PERTURBATIONS D'UN SATELLITE DE LA LUNE DUES A DES TERMES DE LONGITUDE]. B. Morando (Institut Pasteur, Paris, France), p. 163-167. [See A67-21164 08-30]

COLOR PHENOMENA ON THE MOON [LES PHENOMENES COLORES SUR LA LUNE]. P. Swings (Liège, Université, Liège, Belgium), p. 169-174. [See A67-21165 08-30]

NEW SELENOGRAPHIC RESEARCHES [NOUVELLES RECHERCHES SELENOGRAPHIQUES]. J. Hopmann (Wien, Universität, Vienna, Austria), p. 175-185. [See A67-21166 08-30]

A67-21159

SELENODESY AND LUNAR TOPOGRAPHY [SELENODESIE ET TOPOGRAPHIE LUNAIRE].

467-21160

J. Rösch (Observatoire du Pic du Midi, Bagnères-de-Bigorre Hautes-Pyrénées, France).

IN: THE MOON IN THE SPACE AGE [LA LUNE A L'ERE SPATIALE].

Paris, Presses Universitaires de France, 1966, p. 45-55. In French.

Discussion of observation methods aimed at determining the shape of the moon. The determination of the apparent contour of the moon will provide a section of the moon by a plane perpendicular to the earth-moon direction; this section will vary with time due to the libration, because the selenoid is not a perfect sphere and also because there are local irregularities. Another way of determining the shape of the lunar surface in space consists in taking advantage of the libration to attempt to reconstitute in space the relative disposition of the radius vectors connecting the center of the moon to different features on the lunar surface. Lastly, a study of the local topography of features on the surface of the moon will provide needed information. M. F.

A67-21160

NATURE OF THE LUNAR SOIL [LA NATURE DU SOL LUNAIRE].

A. Dollfus (Paris, Observatoire, Meudon, Seine-et-Oise, France).

IN: THE MOON IN THE SPACE AGE [LA LUNE A L'ERE SPATIALE].

Paris, Presses Universitaires de France, 1966, p. 57-103. In French.

Photometric, polarimetric, and IR study of the lunar surface. Subjects discussed include the polarization of the light of the moon, the spectral variation of the polarization, depolarization of the lunar soil, thermal measurements, the action of protons and radiations, measurements by millimeter and centimeter radiations, and study of lunar radar echo signals. M. F.

A67-21165

COLOR PHENOMENA ON THE MOON [LES PHENOMENES COLORES SUR LA LUNE].

P. Swings (Liège, Université, Institut d'Astrophysique, Liège, Belgium).

IN: THE MOON IN THE SPACE AGE [LA LUNE A L'ERE SPATIALE].

Paris, Presses Universitaires de France, 1966, p. 169-174. In French.

Suggestion that reddish lunar spots which have been observed on the moon are due to the escape of ammonia and the formation of NH_2 which becomes fluorescent under solar radiation. This involves the assumptions that nitrogen is stored in some way in a reduced form (possibly as nitrides) beneath the surface of the moon and that water reacts with the nitrides to produce ammonia. F. R. L.

A67-21166

NEW SELENOGRAPHIC RESEARCHES [NOUVELLES RECHERCHES SELENOGRAPHIQUES].

J. Hopmann (Wien, Universität, Universitäts-Sternwarte, Vienna, Austria).

IN: THE MOON IN THE SPACE AGE [LA LUNE A L'ERE SPATIALE].

Paris, Presses Universitaires de France, 1966, p. 175-185. In French.

Discussion of methods of measuring selenographic features. Apparent and true longitudes and latitudes can be obtained by utilization of the stereo effect on at least two photographic plates. Attention is given to the determination of heights and the slopes of crater walls. The method of the limit of illumination of peaks for height determination is described. F. R. L.

A67-21208

LUNAR AND MARTIAN CRUSTS AND MANTLE CONVECTION.

S. Miyamoto (Kyoto, University, Institute of Astrophysics, Kwasan Observatory, Kyoto, Japan).

Icarus, vol. 6, Jan. 1967, p. 50-55. 16 refs.

Study of the crustal features of the moon and Mars in search of probable mantle convections, including a review and interpretation of crustal features. Mantle convection inside planets has an influence on the distribution of continents and ocean basins on the surface. The crustal features suggest that they correspond to mantle convections of spherical harmonics of order one for the moon and of order three for Mars. F. R. L.

A67-21209

A STOCHASTIC MODEL OF THE FORMATION AND SURVIVAL OF LUNAR CRATERS. VI.

Allan H. Marcus (Case Institute of Technology, Cleveland, Ohio).

Icarus, vol. 6, Jan. 1967, p. 56-74. 31 refs.

The distribution of depths of lunar craters can be predicted by a model which takes into account the formation, obliteration, filling, and isostatic readjustment of craters. These theoretical studies suggest more efficient ways of estimating the initial depth-diameter relationship, assuming that the deepest craters are the most recent. The estimated initial depth $H(x)$ of continental craters of diameter x (larger than 15 km) is $H(x) = 1.0x^{0.40}$ and for craters in the maria is $H(x) = 0.75x^{0.50}$, where $H(x)$ and x are in kilometers. As the difference is not significant, there is no reason to believe that many craters in the continents and maria have had different modes of origin. If the crater-forming and crater-filling rates are exponentially decreasing functions of time, and if isostatic readjustment of craters can be neglected, then the distribution of $H(x) - Y$ is a truncated Weibull distribution, where Y is the observed depth of a crater of diameter x . (Author)

A67-21210 *

LUNAR SURFACE STRENGTH.

Leonard D. Jaffe (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

Icarus, vol. 6, Jan. 1967, p. 75-91. 46 refs.

Lower bounds for the strength of the lunar surface have been derived from the properties necessary to provide stability of the slopes observed in Ranger 7, 8, and 9 imagery. Additional information was obtained from Luna 9 data, from hydrostatic considerations, and from laboratory tests. Utilized in some of the calculations were density data derived from radar and thermal emission measurements. Densities obtained are 0.6 to 0.7 g/cm^3 for the top few centimeters, 1 g/cm^3 or more at 10^{-1} m , and 2 to 3 g/cm^3 at 10^0 to 10^1 m . Safe lower bounds for mass-bearing capacity on 0.1-m and 1-m bearing widths are 10^1 and 10^2 g/cm^2 , respectively, with no sinkage, 3×10^1 and 10^3 g/cm^3 with sinkage equal to bearing width. Probably realistic lower bounds for these widths are 10^3 and 10^4 g/cm^3 , respectively; there is a little evidence to suggest representative values are only slightly higher. A model of the surface layer is outlined. (Author)

A67-21216

SYSTEMATIC DETERMINATION OF RELATIVE ALTITUDES ON THE LUNAR SURFACE.

G. A. Mills (Manchester, University, Dept. of Astronomy, Manchester, England).

Icarus, vol. 6, Jan. 1967, p. 131-135. 5 refs.

Grant No. AF EOAR-64; Contract No. AF 61(052)-882.

Use of a coordinate measuring instrument to obtain coordinates for the determination of relative altitudes on the lunar surface. The main advantage of the system is a large increase in speed as compared to the microdensitometer method. The two methods give results differing by less than 100 m at worst. F. R. L.

A67-21361

MEASUREMENTS OF THE DEPTH OF LOOSE AND LOOSELY BONDED MATERIAL ON THE LUNAR SURFACE BASED ON RANGER VII, VIII AND IX PHOTOGRAPHS.

Nils Aall Barricelli and Ralph Metcalfe (Washington, University, Seattle, Wash.).

Planetary and Space Science, vol. 15, Jan. 1967, p. 49-51. 5 refs.

Depth measurements of loose (or loosely bonded) material for the three impact areas of Ranger 7, 8, and 9 by making use of rilles or multiple dimple formations assumed to be caused by loose material draining or crumbling into underground cavities. The existence of a deep layer of loose material on the lunar surface was indicated by results presented by Gold (1955, 1964) and Markov (1962). The notion that there is an upper layer of loose or loosely bonded material covering extensive areas of the lunar surface is in fairly good agreement with the observations made so far.

M.F.

A67-21428 ***THE SURFACE OF THE MOON.**

Albert R. Hibbs (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

Scientific American, vol. 216, Mar. 1967, p. 60-72, 74.

Analysis of pictures of the moon taken by Ranger, Surveyor, and Orbiter spacecraft. Hypotheses concerning the origin and history of the moon are discussed, and data concerning measurements of the lunar libration and temperature, and of optical and radio properties are presented. The Ranger pictures left unresolved the disagreements over the nature of the lunar surface, but demonstrated that there were areas on the moon's surface smooth enough to permit the safe landing of the manned Apollo spacecraft. The message of the Surveyor 1 pictures was that the surface material was granular, at least to the depth penetrated by Surveyor's structure. Several of the pictures made by Orbiter spacecraft provide strong indications that material has moved down the sides of craters. It is pointed out that, although they have revealed much never seen before, these pictures have not solved the riddle of the moon's nature and origin.

M.F.

A67-22013**INFRARED IMAGES OF TYCHO ON DARK MOON.**

John W. Salisbury and Graham R. Hunt (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Bedford, Mass.).

Science, vol. 155, Mar. 3, 1967, p. 1098-1100. 9 refs.

Infrared images of the thermal anomaly associated with the lunar crater Tycho were obtained during the lunar night after Tycho had ceased to be illuminated by the sun for as long as 97 hr. In agreement with results of previous studies, these measurements show that the crater is warmer than its surroundings during the lunar night, and that the temperature of the thermal anomaly gradually decreases with time, being no longer detectable after new moon. This work provides strong evidence that the steeper crater walls facing the sun before local sunset are warmer throughout the cooling phase, and that the Tycho anomaly is thus produced by solar, rather than internal, heat.

(Author)

A67-22405 * #**THE LUNAR SURFACE ACCORDING TO LUNA IX AND SURVEYOR I.**

Rodney W. Johnson (NASA, Advanced Manned Lunar Mission Studies Office, Washington, D.C.).

Astronautica Acta, vol. 12, Sept.-Dec. 1966, p. 370-383. 24 refs.

Analysis and interpretation of Luna 9 and Surveyor 1 data have revealed new information on the character of the lunar surface and at the same time have posed new questions. Though the persistent theory on lunar dust seems to have been settled at last, the controversy regarding vulcanism and meteoritic impact and their contributions to lunar surface features remains as vigorous as it was before these new data were obtained. Significant results include the findings of Luna 9, confirmed by Surveyor 1, that the surface is covered with rock or stone fragments of varying size and distribution over the surface. Colorimetric interpretations derived from Surveyor 1 indicate very somber hues best described as dark greenish-blue and reddish browns. Instead of highly porous or fluffy structure, the surface soil appears to be analogous to a granular media resembling wet beach sand in both behavior and appearance. The most significant data returned from Surveyor 1 derived from analysis of the dynamic touchdown experiment reveal a static bearing capacity of the surface material on the order of 5 psi (350 g/cm²). Landing-dynamics data and penetration depths are compatible also with a hard surface having a static bearing capacity of 10 psi (700 g/cm²) covered

by a weak layer on the order of 25 mm in thickness. These data indicate that, for the location of Surveyor 1 at least, surface bearing conditions are compatible with the Apollo-LM design requirements. On the other hand, the findings show a possible landing hazard based on a frequency distribution of one fragment per 100 m² with a long dimension of one meter or more in the areas surveyed. (Author)

A67-22409 #**LUNAR RESEARCH ON THE MOON.**

Zdenek Kopal (Boeing Co., Scientific Research Laboratories, Seattle, Wash.; Manchester, University, Dept. of Astronomy, Manchester, England) and Wayne A. Roberts (Boeing Co., Aerospace Group, Seattle, Wash.).

Astronautica Acta, vol. 12, Sept.-Dec. 1966, p. 416-424. 10 refs.

Outline of present knowledge of the composition and internal structure of the moon and of its surface environment in so far as it affects ability to establish a lunar base and to define objectives for investigations to be carried out there; and summary of the methods to be used in such work. It is stressed that the main objectives of the first lunar laboratory should be an investigation of the vertical structure of the surface to a depth of 100 to 1000 m by direct methods (drilling) and down to its center by indirect methods, in order to provide a three-dimensional extension to two-dimensional prospecting of the surface from orbiting spacecraft. Points to be kept in mind in connection with the logistic aspects of the lunar base are listed.

(Author)

A67-22689 * #**ULTRAVIOLET REFLECTANCE MEASUREMENTS OF POSSIBLE LUNAR SILICATES.**

Norman N. Greenman, Valerie W. Burkig, and J. Fred Young (Douglas Aircraft Co., Inc., Missile and Space Systems Div., Santa Monica, Calif.).

Journal of Geophysical Research, vol. 72, Feb. 15, 1967, p. 1355-1359. 5 refs.

Contract No. NAS 9-3152.

The reflectance of granitic, gabbroic, and serpentinite rocks in the 2000- to 3000-Å range has been measured to determine whether they display characteristic spectra that could give compositional information about the lunar surface. Measurements were made of solid and granular samples; the granular samples were of three different grain sizes with median diameters of 170-260, 11-16, and 8 μ. Two separate sets of measurements were taken; continuous sample-to-standard comparison curves were obtained with a Cary model 14 recording spectrophotometer, and discontinuous, wavelength-by-wavelength sample-to-direct-beam readings were obtained with a Tropol model N-1 monochromator and reflectometer. The reflectance in almost all cases was found to decline gradually from 3000 to 2500 Å and still more gradually from 2500 to 2000 Å. The gabbroic samples showed the highest reflectance values, but the values of the granitic samples were very nearly the same; serpentinite values were lower for the most part. Typical values for vertical incidence were about 10-14% at 3000 Å and about 4-8% at 2000 Å. Little or no consistent variation with grain size was detected. Ultraviolet-excited luminescence, observed in the samples, may have introduced small errors into some of the measurements. If sharply defined compositional differences exist in this band, they must be in the fine structure of the spectra and may be found only with spectroscopy of higher resolution than was used in these experiments.

(Author)

A67-22692 #**BOULDER DISTRIBUTION ANALYSIS OF THE LUNA 9 PHOTOGRAPHS.**

Bruce G. Smith (Bellcomm, Inc., Washington, D.C.).

Journal of Geophysical Research, vol. 72, Feb. 15, 1967, p. 1398, 1399.

Analysis of the distribution according to sizes of boulders that appear in lunar surface photographs made by the Luna 9 probe. A histogram of boulder distribution for 109 samples and a diagram of surface distribution of boulders are plotted. The results are compared with the results released by the USSR Academy of Sciences.

V. Z.

A67-22746

A67-22746

ENHANCEMENT OF FINE DETAIL IN THE PRESENCE OF LARGE RADIANCE DIFFERENCES.

Graham R. Hunt (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Space Physics Laboratory, Lunar and Planetary Research Branch, Bedford, Mass.).

Applied Optics, vol. 6, Mar. 1967, p. 505-509.

A technique is described for enhancing fine detail in the production of radiance pictures of targets in which large differences also occur, and where the dynamic range of the picture viewing system is limited. This is achieved by scanning a raster with a mirror-chopper fed detector over the target area, and referencing one sampled area on this target against the next, the radiance intensity from which is reduced by a constant factor. The detector output is then a difference curve related to a derivative trace of the radiance profile, superimposed on the true radiance profile reduced in intensity. The method is compared with a similar technique previously used by Low (1965), and examples of the use of the present technique both in the laboratory and in observing a feature on the lunar surface are included. (Author)

A67-22898

A PRELIMINARY SELENOLOGICAL ANALYSIS OF THE RANGER 9 PHOTOGRAPHS.

V. A. Firsoff.

British Astronomical Association, Journal, vol. 77, Feb. 1967, p. 106-111. 8 refs.

Analysis of four Ranger 9 photographs taken before impact on the moon at altitudes of 1240, 412, 184, and 19.52 km, respectively. Marked points on the photographs such as craters and mountain chains are examined, and intriguing features are discussed. To judge by the general appearance, Albategnius appears to be the oldest of the three major rings photographed, followed by Ptolemaeus and Alphonsus. A particular feature of the western wall of Alphonsus is a long shallow depression, recalling the dry bed of a vanished lake, as though it at one time was filled with some liquid which has since evaporated or drained away. M.F.

A67-23360

PHOTOMETRY OF THE LUNAR LIMB ZONES.

N. P. Barabashov, O. I. Belobrova, V. I. Ezerskii, and V. A. Ezerskaia (Khar'kovskii Gosudarstvennyi Universitet, Astronomicheskaya Observatoriia, Kharkov, Ukrainian SSR).

(Astronomicheskii Zhurnal, vol. 43, Sept.-Oct. 1966, p. 1039-1046. Soviet Astronomy, vol. 10, Mar.-Apr. 1967, p. 833-839. 24 refs. Translation.

A67-23361

COLOR CONTRASTS ON THE LUNAR SURFACE.

N. N. Evsiukov (Khar'kovskii Gosudarstvennyi Universitet, Kharkov, Ukrainian SSR).

(Astronomicheskii Zhurnal, vol. 43, Sept.-Oct. 1966, p. 1047-1051.) Soviet Astronomy, vol. 10, Mar.-Apr. 1967, p. 840-843. 7 refs. Translation.

A67-23366

NOMENCLATURE FOR FORMATIONS IDENTIFIED ON THE MOON'S REVERSE SIDE.

Iu. N. Lipskii.

(Astronomicheskii Zhurnal, vol. 43, Sept.-Oct. 1966, p. 1111-1118.) Soviet Astronomy, vol. 10, Mar.-Apr. 1967, p. 889-896. Translation.

A67-23563

LUNAR PHOTOGRAPHY AT PIC DU MIDI OBSERVATORY.

Z. Kopal (Manchester, University, Manchester, England).

Sky and Telescope, vol. 33, Apr. 1967, p. 216-219.

USAF-supported research.

Assessment of lunar photographs obtained with the aid of a 24-in. refractor telescope and a 43-in. reflector telescope at Pic du Midi Observatory. Benefiting from the superb visibility conditions of this observatory, high-quality photographs of the lunar surface are obtained by using long exposure times and monitoring the quality of the image in the course of picture-taking. It is pointed out that although earth-based lunar photography is inferior to spacecraft-based photography with respect to horizontal resolution, it is far superior with respect to vertical resolution, especially in the case of shallow relief. A. B. K.

A67-24457

COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 5 (Numbers 72-78).

Tucson, University of Arizona Press, 1966. 123 p.

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THE INITIAL REDUCTIONS OF MEASURES ON STAR-TRAILED LUNAR PHOTOGRAPHS. D. W. G. Arthur, p. 7-11. [See A67-24458 11-30]

A DEVICE FOR DETERMINING THE INSTANTANEOUS FOCAL LENGTHS OF LARGE TELESCOPES. D. W. G. Arthur, p. 13-16. [See A67-24459 11-14]

SCALE TRANSFER FOR LUNAR PHOTOGRAPHS. D. W. G. Arthur, p. 17, 18. [See A67-24460 11-30]

THE VALIDITY OF SELENOTETIC POSITIONS. D. W. G. Arthur, p. 19-30. 14 refs. [See A67-24461 11-30]

A METHOD FOR DETERMINING THE MOON'S CONSTANTS OF ROTATION FROM MEASUREMENTS ON SCALED AND ORIENTED LUNAR PHOTOGRAPHS. D. W. G. Arthur, p. 31-36. 7 refs. [See A67-24462 11-30]

SELENOTETIC MEASURES ON YERKES LUNAR PHOTOGRAPH NO. 1269. D. W. G. Arthur, p. 37, 38; Catalog. 48 p. [See A67-24463 11-30]

SELENOTETIC MEASURES ON YERKES LUNAR PHOTOGRAPH NO. 482. D. W. G. Arthur, p. 41-43; Catalog. 35 p.

A67-24458

THE INITIAL REDUCTIONS OF MEASURES ON STAR-TRAILED LUNAR PHOTOGRAPHS.

D. W. G. Arthur.

IN: COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 5 (Numbers 72-78).

Tucson, University of Arizona Press, 1966, p. 7-11.

Contract No. AF 19(628)-4332.

Full details are given for the initial reductions of measures on star-trailed lunar photographs. These reductions determine refraction-free photographic coordinates of limb profile points and points on the disk. These coordinates are referred to axes with the origin at the center of the bright limb with the y-axis directed along the moon's hour circle. (Author)

A67-24460

SCALE TRANSFER FOR LUNAR PHOTOGRAPHS.

D. W. G. Arthur.

IN: COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 5 (Numbers 72-78).

Tucson, University of Arizona Press, 1966, p. 17, 18.

Contract No. AF 19(628)-4332.

A method is described for transferring scale from one lunar photograph to another. Selenodetic controls are used, and the effects of systematic and random errors in the positions of the selenodetic points are largely eliminated by choosing a suitable pattern of points. The transfer errors are of the same order as those generally met in selenodetic measures. (Author)

A67-24461 * #**THE VALIDITY OF SELENOTETIC POSITIONS.**

D. W. G. Arthur.

IN: COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 5 (Numbers 72-78).

Tucson, University of Arizona Press, 1966, p. 19-30. 14 refs. Contract No. AF 19(628)-4332; Grant No. NSG 161-61.

Evidence is presented that strong systematic errors in the earthward coordinates of selenotetic points are introduced at all stages of selenotetic triangulation, that is, in the fundamental point determination from heliometer measures, in the determinations of the secondary points, and in the tertiary or photographic triangulations. In contrast, the best photographic triangulations show virtually no evidence of system in the coordinates parallel to the plane of the limb.

(Author)

A67-24462 #**A METHOD FOR DETERMINING THE MOON'S CONSTANTS OF ROTATION FROM MEASUREMENTS ON SCALED AND ORIENTED LUNAR PHOTOGRAPHS.**

D. W. G. Arthur.

IN: COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 5 (Numbers 72-78).

Tucson, University of Arizona Press, 1966, p. 31-36. 7 refs. Contract No. AF 19(628)-4332.

The paper describes a method for determining the moon's constants of rotation and the selenotetic coordinates of a number of primary points starting from rectangular coordinate measures on scaled and oriented lunar photographs. The new features are the use of Mösting A as the origin of selenotetic coordinates and the employment of rigorous formulas in place of the approximate differential formulas of classical selenodesy. The least squares analysis takes into account the algebraic correlation introduced in the reductions of the observed points.

(Author)

A67-24463 #**SELENOTETIC MEASURES ON YERKES LUNAR PHOTOGRAPH NO. 1269.**

D. W. G. Arthur.

IN: COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 5 (Numbers 72-78).

Tucson, University of Arizona Press, 1966, p. 37, 38; Catalog. 48 p. Contract No. AF 19(628)-4332.

Details are given of the measures and reductions for 1868 points on Yerkes lunar photograph No. 1269. The catalog lists the uncorrected photographic coordinates, the refraction-free photographic coordinates, and the standard direction-cosines of 1464 points on the disk. Also given are the uncorrected coordinates and the refraction-free photographic rectangular and polar coordinates of 404 points on the bright limb.

(Author)

A67-24556 #**STATISTICAL MODEL OF A FLOODED RANDOM SURFACE AND APPLICATIONS TO LUNAR TERRAIN.**

Allan H. Marcus (Case Institute of Technology, Cleveland, Ohio).

Journal of Geophysical Research, vol. 72, Mar. 15, 1967, p. 1721-1726. 9 refs.

A mathematical model is developed for a flooded Gaussian surface (singly censored below) as a possible description of rough lunar and planetary terrain on a scale of meters and larger. The model is applied to Jaeger and Schuring's unpublished estimates of the autocorrelation function of terrain in Mare Cognitum photographed by Ranger 7. The theoretical distribution provides a good fit to the observed elevation frequencies in Mare Cognitum. Applications to radar and radio echo studies are considered; the flooded Gaussian surface naturally explains a high radio echo power at low angles of incidence. The flooded Gaussian surface furnishes a much better description of the lunar surface than an unflooded surface or a surface singly censored above.

(Author)

A67-24557 * #**SURFACE STRUCTURE AND MECHANICAL PROPERTIES OF THE LUNAR MARIA.**

Leonard D. Jaffe (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

Journal of Geophysical Research, vol. 72, Mar. 15, 1967, p. 1727-1731. 13 refs.

Strain gage and television data from Surveyor 1, as well as earlier measurements from earth and spacecraft, are consistent with the following characteristics for undisturbed mare surface: a structure composed of individual particles, for the most part 100 μ or less in diameter, and with a small percentage at millimeter-to-meter sizes. The density of the top few centimeters is about 0.7 g/cm³, corresponding to about 25% solid. Static bearing capacity is about 4×10^5 dynes/cm² on a 25-cm bearing diameter with no sinkage, increasing at the rate of about 2×10^4 dynes/cm³ with sinkage. Cohesion is between 10^2 and 10^5 dynes/cm², most probably about 10^3 dynes/cm². Coefficient of internal friction is most probably about 1.5 but may be somewhat lower. The failure mode under bearing load is primarily local shear.

(Author)

A67-24604**TRANSIENT RADIATIVE HEAT EXCHANGE AT THE SURFACE OF THE MOON.**

D. F. Winter (Boeing Co., Boeing Scientific Research Laboratories, Seattle, Wash.).

Icarus, vol. 6, Mar. 1967, p. 229-235. 18 refs.

The surface of the moon is characterized as an evacuated particulate medium in which radiative heat exchange between solid surfaces plays a decisive role in determining the transient behavior of the apparent temperature. A simple model is developed which permits quantitative comparisons with lunar surface temperature variations, observed in the 8 to 12 μ band, both during a lunation and a lunar eclipse. Thermal properties and certain surface characteristics are thereby inferred, including an effective microstructure scale of the order of 0.1 mm.

(Author)

A67-24607 ***SURVEYOR I AND LUNA IX PICTURES AND THE LUNAR SOIL.**

Bruce Hapke (Cornell University, Center for Radiophysics and Space Research, Ithaca, N. Y.).

Icarus, vol. 6, Mar. 1967, p. 254-269. 29 refs. Grant No. NSG-382.

Analysis of Surveyor I and Luna IX photographs of the lunar surface. From a study of photographs obtained with the aid of Surveyor I and Luna IX it is inferred that the lunar surface near the landing sites of both these vehicles consists of fine-grained, moderately cohesive rock powder. In view of the near-universal distribution of this material it is concluded that it is externally generated. No evidence suggesting a change in properties at any depth less than several meters is noted. The morphology of craters generated in the laboratory in fine powders by both impacts and explosions is found to bear a strong resemblance to that seen in the lunar-probe pictures.

A. B. K.

A67-24608 ***DISTRIBUTION OF LUNAR CRATERS ACCORDING TO MORPHOLOGY FROM RANGER VIII AND IX PHOTOGRAPHS.**

Newell J. Trask (U.S. Geological Survey, Menlo Park, Calif.).

Icarus, vol. 6, Mar. 1967, p. 270-276. 10 refs. JPL Contract No. WO 5171.

Morphological classification of the craters photographed by the Ranger 8 and 9 missions. The craters observed are divided into four categories, according to relative sharpness, leading to the conclusion that at diameters of 100 m the predominant craters have broad rims and low depth-diameter ratios and are partly covered with smaller craters, which generally have sharper rims and higher depth-diameter ratios but include all classes. If it is assumed that competing processes of crater formation and destruction are responsible for the mixture of crater types observed, it is concluded that an abrupt increase in the proportion of sharp craters may have resulted from an intense episode of crater destruction which produced a smoothed surface which was subsequently re cratered.

A. B. K.

A67-24609

A67-24609 *

A READILY AVAILABLE MATERIAL FOR THE SIMULATION OF LUNAR OPTICAL PROPERTIES.

Bruce Hapke (Cornell University, Center for Radiophysics and Space Research, Ithaca, N. Y.).

Icarus, vol. 6, Mar. 1967, p. 277, 278.

Grant No. NSG-382.

Results of tests in which a mixture of ordinary Portland cement powder plus a small quantity of cement coloring powder is used to simulate lunar optical properties. It is found that the optical properties of the mixture tested are reasonably similar to those of the lunar surface and that this material may also possess mechanical properties somewhat similar to those of the lunar surface. The main discrepancy noted between the optical characteristics of the powder and the moon is the blue-green color index, which is smaller for the powder than for the moon.

A. B. K.

A67-24844

PREPARATION OF A CATALOG FOR THE INTERPRETATION OF OBJECTS IN THE EASTERN SECTOR OF THE FAR SIDE OF THE MOON [SOSTAVLENIE KATALOGA DESHIFIROVANNYKH OB'EKTOV VOSTOCHNOGO SEKTORA OBRATNOI STORONY LUNY].

L. N. Bondarenko, Iu. N. Lipskii, V. I. Chikmachev, and K. B. Shingareva (Moskovskii Gosudarstvennyi Universitet. Astronomicheskii Institut, Moscow, USSR).

Astronomicheskii Vestnik, vol. 1, Jan.-Mar. 1967, p. 28-31. 6 refs. In Russian.

Discussion of a method for interpreting objects in the eastern sector of the far side of the moon. The 3374 objects identified are listed in catalog form. A classification of craters by size is included.

V. P.

A67-25207

DENSITY OF THE LUNAR SOIL.

John W. Salisbury and Joel E. M. Adler (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Space Physics Laboratory, Bedford, Mass.).

Nature, vol. 214, Apr. 8, 1967, p. 156-158. 9 refs.

Re-evaluation of the problem of probable lunar soil density by extending the work of Hapke and Van Horn. The problem was investigated by sieving clean powders of different materials, with different ranges of grain size, and different drop heights, under ultrahigh-vacuum conditions. It was found that, as the impact velocity rises, the density of powder deposits quickly rises above that of fairy castle structures. There is, however, a limit on the density of powder deposits which is also quickly reached. Based on Hapke's work and the limited amount of data available from the experiments, it appears that reasonable limits of density for the bulk of the uppermost lunar surface lie between about 0.3 and 1.5 g/cm³. Density limits are found to be controlled by grain size, impact velocity, and degree of high-vacuum adhesion, but the most important parameter appears to be grain shape.

M. F.

A67-25463

LUNAR ORBITER READOUT.

A. Jensen, R. J. Witcomb, R. V. Reinke, and D. E. Carson (Eastman Kodak Co., Apparatus and Optical Div., Rochester, N. Y.).

Society of Motion Picture and Television Engineers, Technical Conference and Equipment Exhibit, 101st, New York, N. Y., Apr. 16-21, 1967, Preprint 101-45. 23 p. 5 refs. \$0.75.

Discussion of the readout portion of the photographic system of the Lunar Orbiter, which converts the lunar images into AM video signals. The conversion must be such that the lunar images can be faithfully reconstructed on earth from the video signals with a minimum loss of information. The design effort was directed toward meeting these requirements within the limitations imposed on size, weight, power consumption, and heat dissipation. The major elements of the readout group are briefly described, together with a discussion of special features such as video pre-emphasis, synchronizing techniques, commandable gain and focus adjustments, and temperature compensation. Design problems and their solutions are described. Areas of potential improvement are discussed.

F. R. L.

A67-25464

THE LUNAR ORBITER PHOTOGRAPHIC SYSTEM.

B. L. Elle, C. S. Heinmiller, P. J. Fromme, and A. E. Neumer (Eastman Kodak Co., Apparatus and Optical Div., Rochester, N. Y.).

Society of Motion Picture and Television Engineers, Technical Conference and Equipment Exhibit, 101st, New York, N. Y., Apr. 16-21, 1967, Preprint 101-46. 20 p. \$0.75.

Discussion of the photographic system of the Lunar Orbiter, inherent in the design of which is provision for dual lens photography, film processing, conversion of the film images into video signals for relay through the spacecraft transmitter, and reconstitution of the photographic image on earth after receipt of signals by the orbiter tracking stations. In addition to stringent performance objectives, the equipment design was strongly influenced by such constraints as size, weight, power consumption, pressure and thermal environment, and the limitation on system control and instrumentation. Fundamental to the design was the selection of a suitable film processing chemistry and lenses. The performance photographic requirements for the ground equipment are briefly reviewed.

F. R. L.

A67-25467

FILM PROCESSOR-DRYER FOR LUNAR ORBITER SPACECRAFT PHOTO SYSTEM.

J. J. Meyers, D. Endter, and R. Limoges (Eastman Kodak Co., Apparatus and Optical Div., Rochester, N. Y.).

Society of Motion Picture and Television Engineers, Technical Conference and Equipment Exhibit, 101st, New York, N. Y., Apr. 16-21, 1967, Preprint 101-49. 16 p. \$0.75.

Discussion of high-quality processing and drying of photosensitive film, completely unattended in deep space and in a zero gravity environment. The Kodak Transfer Bimat Film Processing System was selected as the best method for meeting the requirements of Lunar Orbiter. This system is basically a diffusion transfer process in which the processing chemicals, including moisture, are carried in a thin hydrophilic layer which is coated on an Estar Film Base support. This layer is brought into intimate contact with the exposed photosensitive film, at which time processing takes place. In order to maintain a consistently high level of processing quality, the environmental control system for the entire photo system had to be carefully designed. Design and operation are described.

F. R. L.

A67-25646

ON THE THEORY OF LUNAR CRATERS.

A. K. Mukhamedzhanov and K. P. Staniukovich.

(*Kosmicheskie Issledovaniia*, vol. 4, May-June 1966, p. 408-413.) *Cosmic Research*, vol. 4, May-June 1966, p. 361-366. 12 refs. Translation.

A67-25701 *

LABORATORY SIMULATION OF LUNAR SURFACE EROSION BY ROCKETS.

Norman S. Land (NASA, Langley Research Center, Dynamic Loads Div., Environmental Systems Section, Hampton, Va.) and D. William Conner (NASA, Langley Research Center, Dynamics Research Laboratory and Structural Dynamics Branch, Hampton, Va.). IN: INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL TECHNICAL MEETING, 13TH, WASHINGTON, D. C., APRIL 10-12, 1967, PROCEEDINGS. VOLUME 1. [A67-25676 12-11] Mt. Prospect, Ill., Institute of Environmental Sciences, 1967, p. 285-292. 7 refs.

Description of a technique which utilizes models for laboratory simulation of lunar surface erosion by rockets. Various factors involved in this technique are discussed, and some typical results are presented. A brief description is given of the physical characteristics of the jet impinging on a surface, scaling factors considered in devising experiments, experimental apparatus employed, and some typical results.

M. F.

A67-25740 ***PHOTOMETRIC INVESTIGATIONS OF SIMULATED LUNAR SURFACES.**

J. D. Halajian (Grumman Aircraft Engineering Corp., Bethpage, N.Y.).

Journal of the Astronautical Sciences, vol. 14, Jan.-Feb. 1967, p. 1-12. 25 refs.

Contract No. NAS 9-3182.

Experimental attempt to infer certain physical properties of the lunar surface from terrestrial specimens that reproduce the lunation curves of the moon at all viewing angles. An improved photometer capable of examining areas about an order of magnitude larger than previously examined is used to measure the brightness-phase relationship of a number of granular, vesicular and dendritic specimens. Good agreement with the lunar photometric curves at 0, 30 and 60 longitudes is obtained with fine powders, coarse volcanic cinders, furnace slags, scoriae, sea corals, meteorites, etc. The results confirm previous findings with regard to the low albedo and high porosity of the lunar surface but go beyond them in indicating that it is no longer necessary to postulate a layer or veneer of fine dust on the moon in order to account for the lunar photometric data. "Macrorough," cohesive specimens satisfy these data equally well when they are sufficiently dark and porous and are examined by a "large" photometer. The new photometric models are compatible with the apparently dust-free, "underdense-hard" surface revealed by Luna and Surveyor closeup photographs of the moon. (Author)

A67-26006 * #**DIURNAL LUNAR TEMPERATURES.**

Billy P. Jones (NASA, Marshall Space Flight Center, Research Projects Laboratory, Space Thermodynamics Branch, Huntsville, Ala.).

American Institute of Aeronautics and Astronautics, Thermophysics Specialist Conference, New Orleans, La., Apr. 17-20, 1967, Paper 67-289, 13 p. 41 refs.

Members, \$0.75; nonmembers, \$1.50.

Results of theoretical calculations of the temperature distribution in the upper layers of the moon's surface as a function of depth throughout a lunation. These results are compared with measurements of thermal emission in both the IR and microwave regions of the spectrum. The mathematical model used for the analysis is discussed. The temperatures derived from the lunar IR measurements of Sinton (1962), Murray and Willey (1963), and Saari and Shorthill (1966) are discussed and compared with the calculations. Temperatures derived from measurements of thermal emission in the microwave region (0.32 to 20 cm λ) are discussed. Based upon the calculations, which are consistent with both the IR and the microwave measurements, conclusions are drawn regarding the thermal properties of the moon.

R.B.S.

A67-26008 * #**DIRECTIONAL CHARACTERISTICS OF THE LUNAR THERMAL EMISSION.**

N. F. Six, C. G. Montgomery (Brown Engineering Co., Research Laboratories, Huntsville, Ala.), J. M. Saari, and R. W. Shorthill (Boeing Co., Scientific Research Laboratories, Seattle, Wash.).

American Institute of Aeronautics and Astronautics, Thermophysics Specialist Conference, New Orleans, La., Apr. 17-20, 1967, Paper 67-291, 11 p. 5 refs.

Members, \$0.75; nonmembers, \$1.50.

Contract No. NAS 8-20166.

Recent lunar IR scan data have been subjected to a "thermal coordinate" analysis to reveal directional effects caused by lunar surface geometry, angle of solar illumination, and sensor viewing angle. The data are those obtained in the 10- to 12- μ region. Measurements were made simultaneously of the IR radiation and of reflected light at 4450 Å. Brightness temperatures were plotted in polar form for 19 different phases. Besides the most obvious cause of the decay of brightness temperature, T , with angular distance from the subsolar point (the curvature of the moon), the ratio of shadow area to illuminated area within the sensor scan zone accounts for the more gentle decay near full moon. This conclusion implies that shadow areas are cooler than adjacent illuminated areas, meaning lateral heat conduction in the surface layer is poor. Lateral

variations in surface materials, indicated by changes in albedo, explain the local variation in brightness temperature. (Author)

A67-26011 * #**CRYOGENIC STORAGE ON THE MOON.**

Peter E. Glaser and Peter F. Strong (Arthur D. Little, Inc., Cambridge, Mass.).

American Institute of Aeronautics and Astronautics, Thermophysics Specialist Conference, New Orleans, La., Apr. 17-20, 1967, Paper 67-296, 9 p. 20 refs.

Members, \$0.75; nonmembers, \$1.50.

Contract No. NAS 8-11377.

To assess the problems anticipated in storing cryogenic fluids on the surface of the moon for extended periods, heat inputs and the resulting boil-off rates for a hydrogen storage vessel exposed to the lunar environment were estimated. The radiation interchange with the lunar surface was calculated using earth observations of the directional characteristics of the lunar albedo, and the results were compared with calculations made on the basis of an assumption that the lunar surface obeys Lambert's cosine law in reflection. The lunar surface characteristics of importance to cryogenic storage, the selection of appropriate support concepts, the performance of highly effective thermal insulations, and the treatment of piping penetrations to reduce performance degradations are discussed. The results of incident heat flux and boil-off rate computations made with a digital computer program for a typical liquid hydrogen storage vessel are presented. The influence of change in the solar absorptance to emittance ratio of the exterior of the storage vessel, the effectiveness of the multilayer insulation, and the magnitude of the insulation penetration conductance on the boil-off rate are also presented. (Author)

A67-27542**LUNAR SURFACE ACCESSIBILITY FOR MANNED MISSIONS, 1968-1988.**

William D. Kinney, James O. Cappellari, Jr., and James S. Dudek (Bellcomm, Inc., Trajectory Analysis Dept., Washington, D.C.). (American Astronautical Society, Space Flight Mechanics Specialist Conference, University of Denver, Denver, Colo., July 6-8, 1966, Paper 66-131.)

IN: AMERICAN ASTRONAUTICAL SOCIETY, SPACE FLIGHT MECHANICS SPECIALIST SYMPOSIUM, UNIVERSITY OF DENVER, DENVER, COLO., JULY 6-8, 1966, PAPERS.

Symposium sponsored by the American Astronautical Society, the University of Denver, the Office of Aerospace Research of the U.S. Air Force, and the Society for Industrial and Applied Mathematics. Edited by M. L. Anthony.

A67-27602. #**SCHROETER'S RULE AND THE MODIFICATION OF LUNAR CRATER IMPACT MORPHOLOGY.**

Richard J. Pike (Michigan, University, Dept. of Geology and Mineralogy, Ann Arbor, Mich.).

Journal of Geophysical Research, vol. 72, Apr. 15, 1967, p. 2099-2106, 27 refs.

Discussion of the 1:1 correspondence of crater rim volume to true crater volume allegedly observed for many lunar craters which has been explained previously by the theories of explosive meteoritic impact. In fact, it is noted, the equality occurs too infrequently to be of genetic significance. The ratio characteristically is about 0.4 to 0.8 for small, freshly formed lunar and terrestrial craters, but it is well over 1.0 in older and larger lunar craters. Most of the moon's craters are of explosive impact origin and acquire a specific, predictable shape governed by the law of allometric growth. Fresh crater dimensions and volumes are related by expressions of the form $y = ax^b$. Up to a diameter of 10 to 20 km, craters are stable landforms. Larger craters deform isostatically and are further modified by extrusive activity. Application of an allometric fresh crater shape model to Tycho suggests that even the most youthful appearing lunar craters do not long retain their initial rim and true crater volumes, but that they begin to deform soon after impact.

M.M.

A67-28372 #**THEORY OF PROCESSING OF PANORAMIC PHOTOGRAPHS [TEORIJA OBRABOTKI PANORAMNYKH SNIMKOV].**

A67-28373

G. B. Gonin.

IN: PHOTOGRAMMETRIC PROCESSING AND INTERPRETATION OF AERIAL PHOTOGRAPHS [FOTOGAMMETRICHESKAIA OBRA-BOTKA I DESHIFRIROVANIE AEROSNIMKOV].

Edited by G. B. Gonin.

Leningrad, Izdatel' stvo Nauka, 1967, p. 121-135. In Russian.

Discussion of the theory of processing panoramic photographs, such as the ones monitored by the Luna and Surveyor soft-landing lunar probes. The topics discussed in detail are the relation between the coordinates of points on a photograph and the coordinates of the photographed area, the relation between the angular elements in the external orientation of an equivalent planar photograph and the angle of inclination of the panoramic view, the relation between the coordinates of points of the stereo pair and the terrain coordinates, and the determination of the space resection from verticals and astronomical data. Formulas are derived to determine the dimensions of the lunar surface formations shown by the photographs. The accuracy of photogrammetric measurements is assessed. V.Z.

A67-28373

SCANNING AND TRANSFORMATION OF PANORAMIC PHOTOGRAPHS [RAZVERTKA I TRANSFORMIROVANIE PANORAMNYKH SNIMKOV].

G. B. Gonin.

IN: PHOTOGRAMMETRIC PROCESSING AND INTERPRETATION OF AERIAL PHOTOGRAPHS [FOTOGAMMETRICHESKAIA OBRA-BOTKA I DESHIFRIROVANIE AEROSNIMKOV].

Edited by G. B. Gonin.

Leningrad, Izdatel' stvo Nauka, 1967, p. 136-138. In Russian.

Discussion of a technique for idealization of lunar surface photographs monitored by soft-landed probes. The technique is designed to reduce to zero the angular elements of the external orientation of such photographs. Scanning of sections of a panoramic photograph onto a plane and the translation of the obtained scanned sections onto a selected plane are considered. V.Z.

A67-28374 **

A STUDY OF THE DEPOLARIZATION OF LUNAR RADAR ECHOES.

Tor Hagfors (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).

Radio Science, vol. 2, May 1967, p. 445-465. 24 refs.

The radar backscattering characteristics of the lunar surface are examined in detail at a wavelength of 23 cm. The backscattered waves are studied both for circular and for linear polarization of the transmitted wave. Effects relating to the orientation of the local plane of incidence on the moon with respect to the polarization of transmitted or scattered waves are investigated. The experimental results appear to strongly support the hypothesis that the returns at oblique angles of incidence arise through single scattering from discrete objects, as opposed to the returns at near normal incidence which are dominated by quasi-specular reflection. (Author)

A67-28468

STUDY OF THE MOON BY OPTICAL RADAR [ETUDE DE LA LUNE PAR RADAR OPTIQUE].

A. Orszag (Ecole Polytechnique, Paris, France).

IN: PROGRESS IN RADIO SCIENCE 1963-1966; INTERNATIONAL SCIENTIFIC RADIO UNION, GENERAL-ASSEMBLY, 15TH, MUNICH, WEST GERMANY, SEPTEMBER 5-15, 1966, PROCEEDINGS. PART 2 - RADIO ASTRONOMY, RADIO WAVES AND CIRCUITS, AND RADIO ELECTRONICS.

Edited by J. W. Findlay, R. C. Hansen, and R. Burgess.

Berkeley, Calif., International Scientific Radio Union, 1967, p. 2141-2174. 64 refs. In French.

Review of laser techniques as they are applied to lunar studies. The principles for distinguishing between useful signals and noise signals are discussed, and direct detection, the method of signal integration, and the correlation method are studied. The choice of optics (reception optics and emission optics) is considered, and the precision of measurements of the earth-moon distance is evaluated. Other topics discussed include localized measurements, measurements of the lunar radius and of the distance of the center of gravity of the moon, calculation of the lunar parallax, geodesic measurements, study of the small motions of the earth-moon system, the verification of the theory of Hill and Brown, and measurements of the optical properties of the lunar soil. The lunar relief and lunar

gravitation field are studied, and technical problems involved in compensating for the variations of the earth-moon distance and using a high-power Q-switched laser are discussed. M.F.

A67-28506

A SELENOLOGICAL APPRAISAL OF THE ORBITER-2 PHOTOGRAPHS.

V. A. Firsoff.

Spaceflight, vol. 9, Mar. 1967, p. 78-80.

Examination and interpretation of lunar photographs transmitted to the earth by Orbiter-2. A substantial amount of detail was revealed, especially of the averted part of the southern hemisphere (which bears a general resemblance to the earthward part). Very large enclosures with variegated floors nearer the pole present certain unusual characteristics. The southern inside slopes are grooved deeply. Their structure suggests vigorous liquid erosion. Since the "subsoil" of the moon is evidently in a condition of permafrost, underground deposits of ice may be suspected. Because ice does not melt on the moon (it sublimates instead) and because sublimation is a gradual process, the caving in is governed by gravitational forces, resulting in a very regular bowl with a horizontally aligned rim. P.v.T.

A67-28828

ELECTRO-OPTICAL RECTIFIER.

Arnold F. Trachsel (USAF, Aeronautical Chart and Information Center, St. Louis, Mo.).

(American Society of Photogrammetry, Semi-Annual Convention, Dayton, Ohio, Sept. 1965, Paper.)

Photogrammetric Engineering, vol. 33, May 1967, p. 513-524.

The capability of the Fairchild electro-optical rectifier is described in terms of the types of materials that have been generated by the instrument, and the photographic and geometric quality of these products. This new rectifier uses a slit-scan projection method with rectification being accomplished by the programmed motion of the lens and copy platen for transformation of the y-axis perpendicular to the principal line of the photography, and the relative motion between the copy platen and the recording cylinder for transformation on the x-axis along the principal line. Specific examples of various types of frame, strip, and panoramic rectifications of both grid and photographic materials made with the Fairchild rectifier show the operational capability and photographic quality attainable with the instrument. A unique application is the rectification of sections of telescopic photographs of the lunar surface. (Author)

A67-29147

SOME RESULTS OF MEASUREMENTS OF THE COMPLETE STOKES VECTOR FOR DETAILS OF THE LUNAR SURFACE [NEKOTORYE REZUL'TATY IZMERENII POLNOGO VEKTORA STOKSA DLA DETALEI POVERKHNOSTI LUNY].

Iu. N. Lipskii and M. M. Pospergelis (Moskovskii Gosudarstvennyi Universitet, Astronomicheskii Institut, Moscow, USSR).

Astronomicheskii Zhurnal, vol. 44, no. 2, 1967, p. 410-412.

In Russian.

Application of an electronic polarimeter to the measurement of the four Stokes parameters for various features of the lunar surface. The ellipticity of light reflected from the lunar surface is determined. A polarization peculiarity of the Aristarchus crater is detected and is attributed to a cloud of scattering medium above the crater. V.P.

A67-29150

REFLECTION COEFFICIENT FOR ELECTROMAGNETIC WAVES INCIDENT AT VARIOUS ANGLES ON A PLANE LAMINAR MEDIUM OF LUNITE [KOEFFITSIENT OTRAZHENIIA OT PLOSKOSLOISTOI SREDY LUNITA DLA RAZLICHNYKH UGLOV PADENIIA ELEKTROMAGNITNYKH VOLN].

Iu. G. Matveev (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).

Astronomicheskii Zhurnal, vol. 44, no. 2, 1967, p. 419-425. 7 refs. In Russian.

Calculation of the reflection coefficient for electromagnetic waves incident on the lunar surface, assuming that the refractive index varies with depth according to an exponential law. Two structural models of the lunar crust surface are considered for

wavelengths of 3, 10, 30, and 70 cm through the entire range of incidence from 0 to 90°. The values obtained for the reflection coefficient are presented in tabular form. V. Z.

A67-29159

PROPERTIES OF LUNAR SURFACE ROCKS.

Gordon Goles and S. R. Taylor (California, University, Chemistry Dept., La Jolla, Calif.).
Science, vol. 156, May 26, 1967, p. 1134, 1135.

Discussion of the viscosity, volcanic origin and other properties of lunar surface rocks. It is assumed that the Flamsteed Ring has been correctly identified as an extrusive volcanic feature similar to terrestrial ring dikes. However, the high value of the viscosity so derived does not permit one to conclude that the magma is highly acidic on that basis alone. Any conclusion about the acidity or basicity of the putative magma which formed the Flamsteed Ring is mere speculation, as long as there is no information available on the temperature of the magma and on other characteristics. According to the data obtained by the Soviet satellite Luna 10, the lunar surface is a very unlikely source for tektites. Further experiments will be required to solve all problems involved. P. v. T.

A67-29160

SLOPES ON THE MOON.

Daniel J. Milton (U.S. Geological Survey, Menlo Park, Calif.).
Science, vol. 156, May 26, 1967, p. 1135.

Investigation of the formation of the slopes of the Flamsteed Ring on the moon. The profiles of the walls of the Flamsteed Ring are not inconsistent with the presence of noncohesive boulder-sized fragments activated by moon quakes. If the slopes of the Flamsteed Ring are underlain by fragmental debris, this says nothing about the origin of the ring itself and does not preclude its being a ring of coulées. This interpretation of the Flamsteed Ring as the surface expression of a ring dike seems dubious, since there is no terrestrial example to compare with a ring of volcanoes standing isolated on a plain that is level both inside and outside the ring. P. v. T.

A67-29300 *

SCIENTIFIC STUDIES ON THE MOON.

V. B. Morris (Westinghouse Electric Corp., Atomic, Defense and Space Group, Defense and Space Center, Baltimore, Md.), E. J. Sternglass (Westinghouse Electric Corp., Atomic, Defense and Space Group, Research and Development Center, Pittsburgh, Pa.), and R. D. Shelton (NASA, Marshall Space Flight Center, Huntsville, Ala.).
Westinghouse Engineer, vol. 27, May 1967, p. 66-72.
NASA-supported research.

Consideration of a proposed emplaced scientific station (ESS) to be transported to the moon on an unmanned Apollo landing vehicle. Of highest priority will be investigations of the lunar structure and the lunar atmosphere. Following in interest and importance are those investigations directed toward a better understanding of the physical processes on earth. Next in priority are observations relating to the interplanetary medium and the study of nearby planets. Finally, exploration of the universe beyond the solar system will be of great fundamental interest. The ESS would consist of a broadly capable central station supported by three smaller satellite stations. The various devices of which it is composed are described.

F. R. L.

A67-29301

EXPLORING THE LUNAR SURFACE.

Stuart M. Levin.

Space/Aeronautics, vol. 47, May 1967, p. 68-81.

Attempt to anticipate problems which may be encountered while exploring the surface of the moon. It is suggested that attempts be made to plant a coordinated set of instruments on the lunar surface for remote, year-long readout; to bring back lunar samples for exhaustive analysis in custom labs; to go back with wheels, rocket pogos and sophisticated drills for more extensive exploration; and to exploit (eventually) the moon's capacities as a base for astronomy

or as a source for fuel. The need for safety is stressed, and the difficulties still to overcome are pointed out. P. v. T.

A67-29458

FURTHER TESTS FOR RANDOMNESS OF LUNAR CRATERS.

G. Fielder (London, University, Observatory, Mill Hill, Middx., England) and A. Marcus (Cambridge University, Statistical Laboratory, Cambridge, England).

Royal Astronomical Society, Monthly Notices, vol. 136, no. 1, 1967, p. 1-10. 13 refs.

New interpretation of tests for randomness of lunar craters located on the southern floor of Ptolemaeus, facilitated by the negligible effects of obliteration in this region. Distance tests of randomness show that the craters are definitely clustered, and are thus unlikely to be of primary impact origin. Significant values of the index of dispersion of thin strip counts are used to single out any preferred alignments of craters. Preferred trends are found, and it is shown that the majority of the craters forming the chains are of internal, rather than of secondary impact, origin. P. v. T.

A67-29894

RECOGNITION OF LUNAR CRATERS.

James Wilde, James Williams (Kollsman Instrument Corp., Systems Management Div., Syosset, N. Y.), and Jerome Siegel (Kollsman Instrument Corp., Syosset, N. Y.).

Human Factors, vol. 9, Feb. 1967, p. 33-38. 7 refs.

Recognition thresholds for lunar crater size were determined, analytically, for various look angles and magnifications, at an orbital altitude of 80 n mi. Elliptical image measurements for various sized craters were combined with some previous threshold recognition data for the ellipse (Casperson, 1950). Elliptical image measurements consisted of the visual angle of the major axis, and elliptical form (the ratio of minor axis to major axis). A computer program was generated from which the visual angle and form measurements of anticipated elliptical crater images were computed for various combinations of crater size, look angle, and magnification. Casperson's data was then reworked to obtain the visual angle and form measurements associated with his recognition threshold data for the ellipse. By graphically combining the visual angle and form data from both computations, 50% and 75% threshold recognition curves were generated, relating crater size, magnification and look angle. Implications of these data are discussed. (Author)

A67-30102 *

FUTURE LUNAR SURFACE MISSIONS.

H. Wagner and Arnold Schaffer (Grumman Aircraft Engineering Corp., Bethpage, N. Y.).

American Astronautical Society, Symposium on Future Space Programs and Impact on Range Network Development, New Mexico State University, Las Cruces, N. Mex., Mar. 22-24, 1967.

Paper 67-27. 12 p.

Members, \$0.75; nonmembers, \$1.50.

NASA-supported research.

Brief review of the results of studies including the hardware and technology of Apollo Lunar Module (LM). LM is being designed to support two astronauts on the surface of the moon for periods up to 1-1/2 days, and to provide them with up to 300 lb of scientific equipment. The studies have applied the technology and hardware being developed on the LM program to define spacecraft configurations capable of supporting increased lunar surface missions in terms of both staytime and scientific payload. The advanced configurations discussed are presented only as being representative of potential post-Apollo spacecraft configurations. M. M.

A67-30434

AN EARTH-BASED, INFRARED LUNAR MAPPER FOR THERMAL AND COMPOSITION STUDIES.

John D. Rehnberg (Perkin-Elmer Corp., Norwalk, Conn.), John R. Yoder (Barnes Engineering Co., Stamford, Conn.), and Graham R. Hunt (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Bedford, Mass.).
Applied Optics, vol. 6, June 1967, p. 1111-1120. 5 refs.
USAF-supported research.

A67-30643

Equipment was constructed to produce pictorial maps of lunar radiance patterns or of possible variations in lunar surface composition. A motor-driven platform scans a rectangular line raster in the image plane of an astronomical telescope. A liquid helium-cooled copper-doped germanium detector subtending 5" is scanned through a 15' square field. The detector signal modulates a glow lamp, also mounted on the scan platform, which, by synchronously scanning, builds up a pictorial image on polaroid film. When operated in the radiometric mode the equipment produces a pictorial display of lunar thermal patterns. When operated in the compositional-study mode the incoming lunar-emission spectrum is instrumentally compared with the reflection spectrum of mineral specimens. If the spectra are converse, the resulting minimum signal produces a dark area on the map, implying compositional similarity between the lunar surface region and the mineral material. Several pictorial examples are given. (Author)

A67-30643 *

DESIGN AND PERFORMANCE OF THE RANGER BLOCK III UNMANNED LUNAR SPACECRAFT TELEVISION SYSTEM.

M. Benson and R. D. Williams (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

(International Astronautical Federation, International Astronautical Congress, 16th, Athens, Greece, Sept. 13-18, 1965, Paper.)

IN: SPACE CRAFT SYSTEMS; INTERNATIONAL ASTRONAUTICAL FEDERATION, INTERNATIONAL ASTRONAUTICAL CONGRESS, 16TH, ATHENS, GREECE, SEPTEMBER 13-18, 1965, PROCEEDINGS. VOLUME 1. [A67-30622 16-31]

Congress supported by the United Nations Educational, Scientific and Cultural Organization.

Edited by Michal Łunc.

Paris, Gauthier-Villars, Dunod; New York, Gordon and Breach; Warsaw, Państwowe Wydawnictwo Naukowe, 1966, p. 425-449.

11 refs.

A67-30782

EVALUATION OF THE RADIATION ENVIRONMENT ON THE SURFACE OF THE MOON [OTSENKA RADIATIONNOI OBSTANOVKI NA POVERKHNOSTI LUNY].

A. I. Vikhrov, V. E. Dudkin, E. E. Kovalev, and L. N. Smirenniy (Ministerstvo Zdravookhraneniia SSSR, Moscow, USSR).

IN: LIFE IN SPACE CRAFT; INTERNATIONAL ASTRONAUTICAL FEDERATION, INTERNATIONAL ASTRONAUTICAL CONGRESS, 16TH, ATHENS, GREECE, SEPTEMBER 13-18, 1965, PROCEEDINGS. VOLUME 7.

Congress supported by the United Nations Educational, Scientific and Cultural Organization.

Edited by Michal Łunc.

Paris, Gauthier-Villars, Dunod; New York, Gordon and Breach; Warsaw, Państwowe Wydawnictwo Naukowe, 1966, p. 339-343.

10 refs. In Russian.

Evaluation of the level of radiation on the lunar surface with respect to the degree of danger presented to an astronaut. Galactic cosmic radiation and solar particle radiation are discussed from the standpoint of the practical absence of both an atmosphere and a magnetic field. The influence of solar activity periods on the level of these primary sources is described, and the difference between the radiation dose at the lunar surface and during space flight is discussed in terms of the angular distribution of radiation flow. Secondary radiation from isotopes created by the bombardment is analyzed. Tests were conducted to determine the nature and level of this radiation by using two models of lunar-surface composition: (1) a model corresponding to the terrestrial distribution of elements, and (2) a model corresponding to an average meteorite composition. The results showed that the level of radiation is only slightly influenced by lunar isotopes. The degree of original radiation provided by the lunar elements is examined in relation to the shielding presented by the meteorite layer. T. M.

A67-30931 *

LUNAR SURFACE STRENGTH ESTIMATE FROM ORBITER II PHOTOGRAPH.

Alan L. Filice (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

Science, vol. 156, June 16, 1967, p. 1486, 1487.

Interpretation of a portion of frame H-76 obtained by Lunar Orbiter 2. This frame shows a 13-m boulder that had rolled down the inner slope of a 3-km crater, leaving a track 6 m wide. A static-bearing strength of 4×10^6 dynes/cm² at a 75-cm depth is estimated from these data if certain assumptions are made. The effected measurement of crater Sabine D is valuable, because it can be used as a lower limit of bearing strength over a length of 650 m as opposed to the small-footpad type of measurement from a landed spacecraft. A measurement in western Mare Tranquillitatis is also important, because this area is a potential landing site for both Surveyor and Apollo missions to the moon. P. v. T.

A67-30982

AN OPERATIONAL THEORY OF LASER-RADAR SELENODESY.

Robert L. Wildey (U.S. Geological Survey, Flagstaff, Ariz.), Robert E. Schlier, Joseph A. Hull, and Glenn Larson (Avco Corp., Research and Advanced Development Div., Wilmington, Mass.). Icarus, vol. 6, May 1967, p. 315-347. 12 refs.

Proposal of a means of obtaining the ground control upon which the Lunar Orbiter photogrammetry must be based so that Apollo landing sites may be selected. A technique of combining Goldstone tracking data to show where the resulting lunar figure is positioned relative to the moon's center of mass is presented. As far as the measurement of control points is concerned, the use of corner reflectors to be placed on the lunar surface, as suggested earlier, is not essential for the success of this project. Questions regarding the influence of the frozen tide, isostasy, and past impacts of large asteroids on the present shape of the moon appear in large part answerable through data obtainable under the present theory. P. v. T.

A67-30984

TYPES, AGES, AND ORIGINS OF LUNAR RING STRUCTURES - STATISTICAL AND COMPARATIVE GEOLOGICAL APPROACH.

G. N. Katterfeld (Akademiia Nauk SSSR, Komissii po Planetologii, Moscow; Leningradskii Gosudarstvennyi, Universitet, Fakul'tet Geomorfologii, Leningrad, USSR).

Icarus, vol. 6, May 1967, p. 360-380. 46 refs.

Suggestion of a lunar crater classification according to the morphological types of crater. The ring structures of the moon form three distinct groups or associations - craters (which have the largest value of depth-to-diameter ratio), class A cirques (which have continuous walls and comparatively steep slopes), and class B cirques (which are traversed by rills and valleys). The crater region has maximum density; the region of the class B cirques has the least. Two subgroups are named "continental craters" and "ruined craters" according to the height of the crater walls. The origin of craters is discussed. Photographs of a number of analogous terrestrial features are given. P. v. T.

A67-30990

A COMPARISON OF LUNAR PHOTOGRAPHY FROM SPACE PROBES AND GROUND-BASED OBSERVATORIES.

T. W. Rackham (Manchester, University, Dept. of Astronomy, Manchester, England).

Icarus, vol. 6, May 1967, p. 440-444.

Demonstration that ground-based lunar photography at low sun can furnish vertical relief data that are generally unobtainable from spacecraft, unless the spacecraft operates, while overflying the terminator, at the same relative light level. Comparison is made between two photographs of the lunar surface in the region of the ringed plain Ptolemaeus - one exposed with the 43-in. reflector at the Pic-du-Midi Observatory and the other with FB camera of Ranger 9 exposed at an altitude of 1405.6 km above the lunar surface. At least 36 shallow features on the floor of Ptolemaeus are revealed in the 43-in. telescope photograph (solar horizontal attitude ranging between 0° and 2.7°), and these are not shown in the Ranger 9 photograph taken at solar altitude angles of 9.0-11.5°. These two photographs are reprinted. P. v. T.

A67-30992

A NOTE ON THE THERMAL HISTORY OF THE MOON.

Jun Iriyama and Yasuo Shimazu (Nagoya University, Dept. of Earth Sciences, Nagoya, Japan).

Icarus, vol. 6, May 1967, p. 453-457. 6 refs.

Examination of the probable internal structure of the moon in the light of its thermal history, searching for a possible explanation for the formation of the lunar core and crust. Starting from the uniform chondritic sphere 4.5×10^9 years ago, secular variations of the thermal state are calculated. Two alternative initial conditions are considered: the hot model (a uniform 900°K) and the cold model (a uniform 300°K). The surface temperature is kept at 273°K . When the temperature rises beyond the melting temperature of iron, the iron core is assumed to be formed. When the temperature rises beyond the melting point of diopside, ascending of crustal materials occurs.

P.v.T.

A67-31008

FUEL SUPPLY ON EXTRATERRESTRIAL LUNAR AND PLANETARY SUPPORT STATIONS [TREIBSTOFFVERSORGUNG AUF AUSSERIRDISCHEN MOND- UND PLANETENSTÜTZPUNKTEN].

Eckart W. Schmidt (Rocket Research Corp., Seattle, Wash.).

DGRR, *Mitteilungen*, vol. 20, May 1967, p. 7-10. 8 refs. In German.

Discussion concerning the possibility of producing rocket fuel on the surface of the moon and certain planets of the solar system for eventual use in lunar and planetary explorations. Two methods of fuel production on the moon are proposed: (1) the electrolysis of water and (2) the treatment of oxide rock. Since the question concerning the water content of lunar rock is still unanswered, the feasibility of the first method cannot be determined. Two power sources for the operation of the fuel factory are examined: (1) solar radiation and (2) nuclear energy. The feasibility of producing fuel on Mars, Venus, Mercury, Jupiter, and on asteroids is briefly touched upon.

R. B. S.

A67-31199 =

EXPLORATION OF THE MOON WITH UNMANNED PROBES [DIE ERFORSCHUNG DES MONDES MIT UNBEMANNTE SONDEN].

Friedolin Fuxberger (Österreichische Gesellschaft für Flugkörper-technik, Vienna, Austria).

Weltraumfahrt Raketentechnik, vol. 18, Jan.-Feb. 1967, p. 5-13.

In German.

Chronological summary of the results of the exploration of the moon, including pictures of the devices used and of the moon's surface. Starting with the Soviet moon probe Luna I in January 1959, there began a series of Soviet and American experiments having the purpose of transporting measuring devices into the vicinity of the moon or landing them on the moon's surface. Up to the end of 1966, 26 moon probes were made, 13 of which transmitted measured data or pictures of the moon's surface. The American moon probes of the Ranger, Surveyor, and Lunar Orbiter types, as well as the Soviet Luna series succeeded in transmitting insights into the structure of the moon's surface, views of the back side of the moon, and a great deal of theoretical knowledge concerning the types of matter existing on the moon.

P.v.T.

A67-31495 #

POLARIZATION CHARACTERISTICS OF THE RADIO EMISSION FROM A MOON WITH A ROUGH SURFACE WITH ALLOWANCE FOR THE AVERAGING EFFECT OF THE ANTENNA RADIATION PATTERN [POLARIZATSIONNYE KHARAKTERISTIKI RADIOIZLUCHENIIA SHEROKHOVATOI LUNY PRI UCHETE USREDNIA-IUSHCHEGO DEISTVIA DIAGRAMMY NAPRAVLENNOSTI ANTEN- NY].

V. A. Alekseev, T. N. Alechina, and V. D. Krotikov (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).

Radiofizika, vol. 10, no. 5, 1967, p. 603-607. 5 refs. In Russian.

Analysis of the averaging effect of the antenna radiation pattern on the polarization characteristics of lunar radio emission, under the assumption that the lunar surface is smooth for radio waves. The results are extended to include the effect of lunar surface roughness by introducing a mean statistical emissivity. It is shown that near the lunar limb, the polarization characteristics are strongly influenced by the dispersion of the angles of inclination of the surface roughnesses and that for certain antenna beam widths, the magnitude of lunar surface roughness can be determined from these characteristics.

V. P.

A67-31743 * #

PROTON-IRRADIATION DARKENING OF ROCK POWDERS - CONTAMINATION AND TEMPERATURE EFFECTS, AND APPLICATIONS TO SOLAR-WIND DARKENING OF THE MOON.

Douglas B. Nash (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

Journal of Geophysical Research, vol. 72, June 15, 1967

p. 3089-3104. 55 refs.

Darkening of silicate rock powders by bombardment with 2 to 16-keV protons was found to be slight unless proton flux or total proton incident-power density is sufficient to produce sample surface temperature in excess of about 150°C . Darkening then increases with incident power density for a given proton dose - i.e., the darkening is rate-dependent as well as dose-dependent. The darkening is due to contamination by (1) carbon from irradiation decomposition of hydrocarbon vacuum contaminants and/or (2) metal atoms deposited on the sample surface from sputtering of ion source components. The photometric properties of the contamination-darkened samples are similar to those reported for samples darkened with hydrogen ions by Hapke and by Wehner et al. This result suggests that contamination darkening may have caused the photometric modifications that they report; a review and comparison of experimental apparatus and procedures is presented. The experimental conditions under which silicate powders darkened by proton or hydrogen-ion bombardment are shown to be unrealistic for simulation of solar-wind darkening of the moon's surface. It is suggested, however, that deposition of solar carbon on the moon may occur in sufficient amounts to produce darkening.

(Author)

A67-31744 * #

PARAMETERS OF THE OPTICAL PROPERTIES OF THE LUNAR SURFACE POWDER IN RELATION TO SOLAR-WIND BOMBARDMENT.

C. E. KenKnight, D. L. Rosenberg, and G. K. Wehner (Litton Industries, Inc., Applied Science Div., Minneapolis, Minn.).

Journal of Geophysical Research, vol. 72, June 15, 1967,

p. 3105-3129. 53 refs.

Contract No. NASw-751.

The optical properties of the moon are quantitatively compared with those of powder samples bombarded by ions from a hydrogen discharge plasma. Deficiencies in the simulation of the solar-wind bombardment include contaminants deposited on, and injected into, the sample surfaces. Also an unknown function of the sputtered atoms returns to the lunar surface after flight in the gravity field. The variable albedo of the powder samples due to darkening by ion bombardment is studied in relation to parameters of color, photometric function, and polarization while holding composition, surface structure, or powder particle size fixed. Simulation of the solar wind was not adequate to permit identification of lunar compositions from lunar color. The lunar photometric function requires a rough macrostructure. A number of properties of the photometric function plus the polarization of earthshine, however, are shown to be incapable of presently proving whether the lunar surface is underdense or compacted. A polarization parameter indicates a lunar powder whose particles are mostly less than 0.1 mm in size. Effects expected from solar-wind bombardment include surface darkening and decoloration, erosion, preferential erosion of some substances, dust cementation, and alterations of surface layer composition.

(Author)

A67-31749 * #

POLARIMETRIC MEASUREMENTS OF SIMULATED LUNAR SURFACES.

W. G. Egan (Grumman Aircraft Engineering Corp., Research Dept., Bethpage, N.Y.).

Journal of Geophysical Research, vol. 72, June 15, 1967, p. 3233-3245. 21 refs.

Contract No. NAS 9-4942.

Consideration of the polarimetric properties of simulated lunar surfaces. It is shown that the polarization properties of the lunar surface can be produced by Haleakala volcanic ash or blast furnace slag with a particulate coating of itself. It is concluded that (1) the smallest particles of the range studied have higher albedos and lower maximum polarization than the largest particles of the same materials; (2) an inverse relationship between the maximum percent

A67-32388

polarization and spectral albedo is found to exist for the contrived models; and (3) for higher maximum percent polarization, the corresponding phase angle increases. B.B.

A67-32388

AN ANALYSIS OF LUNAR EVENTS.

Barbara M. Middlehurst (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).

Reviews of Geophysics, vol. 5, May 1967, p. 173-189. 42 refs.

NSF Grants No. GP-5940; No. GP-6709.

Investigation of the relationship between the onset of lunar events and a disturbance of the lunar crust. Events taking place during the 18th, 19th, and 20th centuries are analyzed from the following points of view: (1) type of event; (2) relative frequency and duration; (3) lunar phase; (4) correlation with solar activity; (5) position in the lunar orbit around the earth; (6) positions of the sites of the events on the face of the moon. The distribution of sites over the lunar surface is consistent with a hypothesis of disturbance of the surface layers through internal causes. It is pointed out that physical conditions in the lunar surface layers are largely unknown and that many uncertainties remain. R.B.S.

A67-32757

ON THE STRUCTURE OF THE MOON.

Harold Jeffreys.

Royal Astronomical Society, Monthly Notices, vol. 136, no. 3, 1967, p. 311, 312.

Elaboration of one of Eckert's results on the moon's moments of inertia. It is pointed out that a straightforward interpretation of this result, which was given as an entry in a table without special comment, leads to the finding that there is a thick layer near the surface with a density greater than that of lead. M.M.

A67-32966

FIRST PANORAMIC VIEWS OF THE LUNAR SURFACE [PERVYE PANORAMY LUNNOI POVERKHNOSTI].

Edited by Iu. I. Efremov.

Moscow, Izdatel'stvo Nauka, 1966. 154 p. In Russian.

Description of the soft landing of Lunik 9 on the surface of the moon, on Feb. 3, 1966, documented by an exact reproduction of photographs taken there and sent back to earth. Some details of the construction of Lunik 9 are given, as well as the course of its flight to the moon. As a result of the soft landing of Lunik 9, further details could be learned concerning the topography of the moon near the landing site, which appeared to be a rather even surface with a clearly designed relief and with hills rising on the horizontal line. The mesorelief is characterized by a great number of craters and hollows, of the most varied sizes, so that no system for classifying them could be worked out. Abundant data concerning the morphological and geological characteristics of the landing site are presented. P.v.T.

A67-32976

INVESTIGATION OF REFLECTION OF METER RADIO WAVES FROM THE LUNAR SURFACE [ISSLEDOVANIYE OTRAZHENII METROVYKH RADIOVOLN POVERKHNOST'IU LUNY].

O. I. Iakovlev and A. I. Efimov (Akademiia Nauk SSSR, Institut Radiotekhniki i Elektroniki, Moscow, USSR).

Akademiia Nauk SSSR, Doklady, vol. 174, May 21, 1967, p. 583, 584. In Russian.

Brief note on measurements from Aug. 30 through Sept. 27, 1966, of reflection and scattering for 1.7-m radio waves emitted onto the lunar surface by the lunar orbiter Luna 11. Preliminary results of an analysis of the wave-reflection- and -scattering spectra are also given. V.Z.

A67-33094

SOME COMMENTS ON THE CLOSE-UP VIEWS OF THE LUNAR GROUND.

V. A. Firsoff.

British Astronomical Association, Journal, vol. 77, June 1967, p. 251-255.

Discussion of the lunar photographs taken by Luna 9 and Surveyor I, revealing linear and circular ground features and

showing rock blocks and dust. The character of the parts of Oceanus Procellarum photographed by the two probes is generally similar, but the landing area of Luna 9 seems to be much rougher, more highly porous, and utterly lacking in any overlay. It seems clear that the lunar ground in this region has sufficient mechanical strength to drive a jeep over, not to mention walking or running under reduced gravity. The splintering shown indicates a stiff brittle texture, resembling that of porous glass or ceramic. The topmost layer of the lunar ground is subject to considerable volume variation, due to the temperature changes over a range of some 150°C, causing it to peel off the subjacent rocks, which also lie at the permafrost level. P.v.T.

A67-33118

FIGURE AND MOTION OF THE MOON [FIGURA I DVIZHENIE LUNY].

Edited by A. A. Iakovkin.

Kiev, Izdatel'stvo Naukova Dumka, 1967. 204 p. In Russian.

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SYSTEMS FOR LUNAR-SURFACE DETAIL POSITIONS [O SISTEMAKH POLOZHENII DETALEI LUNNOI POVERKHNOSTI]. I. V. Gavrilov, p. 56-61. 9 refs. [See A67-33120 17-30]

DETERMINATION OF THE ROTATIONAL PARAMETERS OF THE MOON BY A METHOD INDEPENDENT OF THE LUNAR-LIMB RELIEF [OPREDELENIE PARAMETROV VRASHCHENIIA LUNY METODOM, NEZAVISYASHCHIM OT REL'EFA KRAEVOI ZONY LUNY]. A. A. Gorynia, p. 62-97. [See A67-33121 17-30]

EFFECT OF THERMAL CONDITIONS ON THE FIGURE OF THE MOON [VLIYANIE TERMICHESKIKH EFFEKTOV NA FIGURU LUNY]. B. Iu. Levin, p. 98-104. 23 refs. [See A67-33122 17-30]

FIGURE OF THE MOON [K VOPROSU O FIGURE LUNY]. V. S. Safronov, p. 105-117. 7 refs. [See A67-33123 17-30]

COMPARISON OF LUNAR PROFILES REFERRED TO A SYSTEM OF REFERENCE POINTS AND LIMB-REGION MAPS [SRAVNENIE PROFILEI LUNY, OTNESENNYKH K SISTEME BAZISNYKH TOCHEK, S KARTAMI KRAEVOI ZONY]. A. S. Duma, p. 118-126. 9 refs. [See A67-33124 17-30]

DERIVATION OF THE CONSTANTS OF PHYSICAL LIBRATION OF THE MOON FROM THE HELIOMETRIC OBSERVATIONS OF KRASNOV, TAKING INTO ACCOUNT THE LARGE RELIEF [VYVOD POSTOYANNYKH FIZICHESKOI LIBRATSII LUNY IZ GELIOMETRICHEKSKIKH NABLIUDENII A. V. KRASNOVA S UCHETOM BOL'SHOGO REL'EFA]. D. P. Duma, p. 127-130. 6 refs. [See A67-33125 17-30]

EFFECT OF LIBRATIONS ON THE RADIUS OF THE MOON ACCORDING TO THE HELIOMETRIC OBSERVATIONS OF SCHLÜTER [LIBRATSIONNYI EFFEKT V RADIUSE LUNY IZ GELIOMETRICHEKSKIKH NABLIUDENII SHLIUTERA]. L. N. Miz', p. 131-150. 6 refs. [See A67-33126 17-30]

SOME RESULTS OF AN EXAMINATION OF THE WATTS MAPS [NEKOTORYE REZUL'TATY ISSLEDOVANIA KART UOTTS]. D. P. Duma and A. S. Duma, p. 151-169. 27 refs. [See A67-33127 17-30]

EXPERIMENTAL DETERMINATION OF THE ORIENTATION ELEMENTS OF THE FK3 CATALOG FROM SHORT SERIES OF LUNAR OBSERVATIONS [OPYT OPREDELENIIA ELEMENTOV ORIENTATSII KATALOGA FK3 IZ KOROTKIKH RIADOV NABLIUDENII LUNY]. D. P. Duma, p. 170-176. 14 refs. [See A67-33128 17-30]

DETERMINATION OF THE DIFFERENCE BETWEEN EPHEMERIS AND UNIVERSAL TIME ACCORDING TO THE OCCULTATION OF STARS BY THE MOON IN 1959 [OPREDELENIE RAZNOSTI MEZHDU EFEMERIDNYM I VSEMIERNYM VREMENEM PO NABLIUDENIAM POKRYTIY ZVEZD LUNOI V 1959 g.]. E. M. Izhaevich, p. 177-189. 17 refs. [See A67-33129 17-30]

MOTION OF THE LUNAR IMAGE IN HORIZONTAL TELESCOPES WITHOUT A COELOSTAT ARRANGEMENT [O DVIZHENII IZOBRAZHENIIA LUNY V GORIZONTAL'NYKH TELESKOPAKH BEZ TSELOSTATNOI USTANOVKI]. V. S. Kisliuk, p. 190-201. 11 refs. [See A67-33130 17-30]

A67-33119 #

CATALOG OF SELENOCENTRIC POSITIONS FOR A TOTAL OF 500 REFERENCE POINTS ON THE LUNAR SURFACE [KATALOG SELENOTSENTRICHESKIKH POLOZHENII 500 BAZISNYKH TOCHEK NA POVERKHNOSTI LUNY].

I. V. Gavrilov, A. S. Duma, and V. S. Kisliuk.

IN: FIGURE AND MOTION OF THE MOON [FIGURA I DVIZHENIE LUNY].

Edited by A. A. Iakovkin.

Kiev, Izdatel'stvo Naukova Dumka, 1967, p. 7-55. 7 refs. In Russian.

- Note on a catalog of lunar-surface features compiled by the Main Astronomical Observatory of the Ukrainian SSR at Goloseevo. The reference points covered by the catalog include 406 craters, 30 individual peaks, and 64 spots of unknown nature, as well as their selenocentric rectangular coordinates, selenographic longitudes and latitudes, and absolute altitudes. V.Z.

A67-33120 #

SYSTEMS FOR LUNAR-SURFACE DETAIL POSITIONS [O SISTEMAKH POLOZHENII DETALEI LUNNOI POVERKHNOSTI].

I. V. Gavrilov.

IN: FIGURE AND MOTION OF THE MOON [FIGURA I DVIZHENIE LUNY].

Edited by A. A. Iakovkin.

Kiev, Izdatel'stvo Naukova Dumka, 1967, p. 56-61. 9 refs. In Russian.

Consideration of the accuracy and practical value of the Schrutka-Rechtenstamm coordinate system of lunar-surface characteristic-point positions. Corrections are given for conversion of lunar detail positions from this coordinate system into the more accurate Watts lunar-limb coordinate system. V.Z.

A67-33121 #

DETERMINATION OF THE ROTATIONAL PARAMETERS OF THE MOON BY A METHOD INDEPENDENT OF THE LUNAR-LIMB RELIEF [OPREDELENIIE PARAMETROV VRASHCHENIIA LUNY METODOM, NEZAVISIASHCIM OT REL'EFA KRAEVOI ZONY LUNY].

A. A. Gorynia.

IN: FIGURE AND MOTION OF THE MOON [FIGURA I DVIZHENIE LUNY].

Edited by A. A. Iakovkin.

Kiev, Izdatel'stvo Naukova Dumka, 1967, p. 62-97. In Russian.

Results of refractometric observations of the position angles of a group of 27 lunar craters conducted from August 1963 through September 1964 in an attempt to determine the libration parameter of the moon by a method more accurate than lunar-limb-relief observations. Tabulated results are given for selenographic and topocentric coordinates, apparent position angles, and corrections for conversion from an ecliptic to an equatorial coordinate system. V.Z.

A67-33122 #

EFFECT OF THERMAL CONDITIONS ON THE FIGURE OF THE MOON [VLIANIE TERMICHESKIKH EFFEKTOV NA FIGURU LUNY].

B. Iu. Levin.

IN: FIGURE AND MOTION OF THE MOON [FIGURA I DVIZHENIE LUNY].

Edited by A. A. Iakovkin.

Kiev, Izdatel'stvo Naukova Dumka, 1967, p. 98-104. 23 refs. In Russian.

Review and assessment of current methods of determining the figure of the moon. It is pointed out that the large inertial moment of the moon with respect to its polar axis is in conformity with its flattened geometric form and that thermal effects may be the cause of the flatness. V.Z.

A67-33123 #

FIGURE OF THE MOON [K VOPROSU O FIGURE LUNY].

V. S. Safronov.

IN: FIGURE AND MOTION OF THE MOON [FIGURA I DVIZHENIE LUNY].

Edited by A. A. Iakovkin.

Kiev, Izdatel'stvo Naukova Dumka, 1967, p. 105-117. 7 refs. In Russian.

Discussion of the isostatical "equilibrium" form of a model of the moon consisting of a homogeneous semimolten core and homogeneous solid crust. The crust is slightly thicker at the poles than at the equator and slightly denser than the core. The elastic stresses that arrest vertical displacements and crust-shape alterations are in a state of complete relaxation, and the elastic forces in the crust surface arrest horizontal displacements of the crust substance and the restoration of the surface leveling. A core and a crust bounded by both spheroidal and other-than spheroidal surfaces are considered V.Z.

A67-33130 #

MOTION OF THE LUNAR IMAGE IN HORIZONTAL TELESCOPES WITHOUT A COELOSTAT ARRANGEMENT [O DVIZHENII IZO-BRAZHENIIA LUNY V GORIZONTAL'NYKH TELESKOPAKH BEZ TSELOSTATNOI USTANOVKI].

V. S. Kisliuk.

IN: FIGURE AND MOTION OF THE MOON [FIGURA I DVIZHENIE LUNY].

Edited by A. A. Iakovkin.

Kiev, Izdatel'stvo Naukova Dumka, 1967, p. 190-201. 11 refs. In Russian.

Solution of the problem of the motion of lunar images in the focal plane of a horizontal telescope without a coelostat arrangement. Formulas are given for determining the setting of the mirror at the moment of observation, the rate of motion of the image, and the angle of inclination of the vector of this velocity to the horizon line in the image on the plate. In conclusion, a formula is given for the determination of the curvature of the diurnal parallel image. P. v. T.

A67-33250 *

ON THE DETECTION OF WATER ON THE MOON.

M. Werner, T. Gold, and M. Harwit (Cornell University, Center for Radiophysics and Space Research, Ithaca, N. Y.).

Planetary and Space Science, vol. 15, Apr. 1967, p. 771-774. 21 refs.

NSF Grant No. GP-1138; Grant No. NSG-382; Contracts No. AF 49(638)-1527; No. NSR-33-010-026.

Discussion of Gold's suggestion that a permafrost layer may exist beneath the surface of the moon. It is pointed out that, if such a layer were present, H₂O molecules would be outgassing from the lunar surface. These molecules could be detected by observations of fluorescent radiation from OH radicals produced from the H₂O by radiative dissociation. It is shown that an outgassing rate from such a lunar permafrost layer as low as 3×10^7 molecules/cm²-sec could be detected from the surface of the earth. M.F.

A67-33364 *

BISTATIC-RADAR DETECTION OF LUNAR SCATTERING CENTERS WITH LUNAR ORBITER I.

G. L. Tyler, V. R. Eshleman, G. Fjeldbo, H. T. Howard, and A. M. Peterson (Stanford University, Center for Radar Astronomy, Stanford, Calif.).

Science, vol. 157, July 14, 1967, p. 193-195.

Grant No. NSG-377.

Continuous-wave signals transmitted from Lunar Orbiter 1 have been received on earth after they have been reflected from the surface of the moon. The frequency spectrum of the reflected signals is used to locate discrete, heterogeneous, scattering centers on the lunar surface. The scattering centers are probably distinguished from the surrounding terrain by a higher surface reflectivity. Continuous-wave bistatic radar could provide an important new method for the study and mapping of planetary surfaces. (Author)

A67-33861

PRECISE MEASUREMENT OF LUNAR RADIO EMISSION AT 1.8, 2, AND 2.5 CM.

V. M. Plechkov (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).

(Astronomicheskii Zhurnal, vol. 44, Jan.-Feb. 1967, p. 154-157.)

Soviet Astronomy, vol. 11, July-Aug. 1967, p. 119-121. 11 refs.

Translation.

Measurement of the lunar radio emission at 1.8, 2, and 2.5 cm for the purpose of determining the attenuation in lunar matter of wavelengths close to 1.6 cm. The measurements were made by the

A67-33866

"artificial moon" method and yielded the following phase dependences of effective lunar temperature, averaged for the disk: at 1.8 cm $T_{\text{moon}} = 202^\circ + 24^\circ \cos(\Phi - 30^\circ)$; at 2.0 cm $T_{\text{moon}} = 206^\circ + 19^\circ \cos(\Phi - 56^\circ)$; at 2.5 cm $T_{\text{moon}} = 210^\circ + 15.5^\circ \cos(\Phi - 42^\circ)$. The lunar phase Φ is computed from the full moon. The accuracy of the measurements for the absolute lunar temperature is $\pm 5\%$. T. M.

A67-33866

GEOCENTRIC TRAJECTORIES FOR PARTICLES OF A SINGLE CLASS.

V. P. Orlov (Odesskii Gosudarstvennyi Universitet, Astronomicheskaya Observatoriia, Odessa, Ukrainian SSR). (Astronomicheskii Zhurnal, vol. 44, Jan.-Feb. 1967, p. 217-226.) Soviet Astronomy, vol. 11, July-Aug. 1967, p. 166-172. 17 refs. Translation.

Computation of elements for 1800 geocentric trajectories of particles ejected by meteoritic impact from the lunar surface toward the lunar zenith at various longitudes within the moon's orbital plane. Curves are drawn for the perigee distance and velocity as functions of the initial particle velocity and ejection longitude. A range of initial conditions ensuring that a particle will strike the earth is determined. The trajectories are computed by the sphere-of-influence approximation. The maximum lunar-particle influx on the earth would be expected 4 to 7 days after the activity maximum of meteor streams overtaking the moon. M.M.

A67-33998

SPATIAL FILTERING OF ASTRONOMICAL PHOTOGRAPHS.

Robert L. Willey (U.S. Geological Survey, Astrogeology Branch, Flagstaff, Ariz.). Astronomical Society of the Pacific, Publications, vol. 79, June 1967, p. 220-225.

A primary problem in devising optical systems to alter the relative harmonic coefficients in a two-dimensional Fourier series representation of a photograph (considered as a functional form of brightness vs two space coordinates) is presented by the coherence of the light sources used to obtain a plane waveform. Such a series is truncated by the finite entrance pupil of the optical processing system. The ringing effects that result prevent application of the technique to imagery. A device has been built to alleviate this

A67-34135

THE SURFACES OF THE MOON, MARS AND VENUS.

Donald H. Menzel (Harvard University, Harvard College Observatory, Cambridge, Mass.).

IN: MOON AND PLANETS; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 7TH, VIENNA, AUSTRIA, MAY 10-18, 1966, PAPERS.

Symposium sponsored by the Committee on Space Research and the International Astronomical Union.

Edited by A. Dollfus.

Amsterdam, North-Holland Publishing Co., 1967, p. 1-6.

Discussion of the origin of the surface of the moon, and of the present state of the surfaces of the moon, Venus, and Mars, as determined from lunar photographs and from data obtained by the fly-by probes of Venus and Mars made by Mariners 2 and 4. It is suggested that the surface of the moon is much older than has been expected. Perhaps most of the craters were formed when the moon was still young and possessed a large liquid core. Under such conditions, puncturing the thin solid surface could cause lava inundations that would produce major erosions, thus explaining the irregularities in the shape of the moon. The radio observations of Venus indicate a very hot surface and infrared studies point to the presence of small amounts of water vapor. The probing of Mars revealed a cratered surface resembling that of the moon. P.v.T.

A67-34137

THE LUNAR SURFACE AND THE U.S. RANGER PROGRAM.

Gerard P. Kuiper (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).

IN: MOON AND PLANETS; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 7TH, VIENNA, AUSTRIA, MAY 10-18, 1966, PAPERS.

Symposium sponsored by the Committee on Space Research and the International Astronomical Union.

Edited by A. Dollfus.

Amsterdam, North-Holland Publishing Co., 1967, p. 23-44. 19 refs.

Review of the significance and interpretation of the 17,000 records obtained by Ranger flights 7, 8, and 9. These are interpreted with the aid of the best earth-based photographs of the moon and extensive studies of terrestrial lava fields. On the basis of these data, the igneous nature of the maria is regarded as entirely established, with many of the curious physical properties determined from thermal, radio, and radar experiments explained as due to the structure of lava deposited in a vacuum. (Author)

A67-34138

SCIENTIFIC RESULTS OF AN ANALYSIS OF LUNAR SURFACE PANORAMAS.

A. I. Lebedinskii (Akademiia Nauk SSSR, Moscow, USSR).

IN: MOON AND PLANETS; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 7TH, VIENNA, AUSTRIA, MAY 10-18, 1966, PAPERS.

Symposium sponsored by the Committee on Space Research and the International Astronomical Union.

Edited by A. Dollfus.

Amsterdam, North-Holland Publishing Co., 1967, p. 45-50.

Summary of the book "First Panoramas of the Lunar Surface," published by the Academy of Sciences of the USSR (Moscow, 1966). The automatic station Lunik 9, which made a soft landing on the moon, transmitted three panoramas. The first panorama encompasses the entire horizon. Due to an increase in the inclination of the station during subsequent panoramic scanings, the western horizon was not in view. The panoramic photographs show the structure of the lunar surface very well, permitting a study of the morphological and geological features of the landing site. Apart from clearly defined forms, the panoramas reveal intermediate, compound, and atypical details, which evidently resulted from the recurrent action of different processes, both of endogenic and exogenous nature. The latter occur as a result of meteoritic and stone impacts and impacts by solar wind particles. The dominant type of relief in the section studied is that of depressed forms - rounded holes typical of the entire lunar surface. P.v.T.

A67-34139

THE LUNAR SURFACE ABSORPTION SPECTRUM IN THE RANGE OF 0.8-13 μ .

M. N. Markov and V. L. Khokhlova (Akademiia Nauk SSSR, Moscow, USSR).

IN: MOON AND PLANETS; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 7TH, VIENNA, AUSTRIA, MAY 10-18, 1966, PAPERS.

Symposium sponsored by the Committee on Space Research and the International Astronomical Union.

Edited by A. Dollfus.

Amsterdam, North-Holland Publishing Co., 1967, p. 53-58.

Measurements of the absorption coefficient of the lunar surface in the infrared range is of great value for the study of the chemical composition and structure of the surface. A special method was used to separate reflected solar radiation from thermal radiation of the moon itself in the wavelength $\lambda = 3.5 \mu$ during the eclipse. The absence of limb-darkening in reflected light in $\lambda = 3.5 \mu$ was established. Reflectivity for different points on the moon and the temperature of a subsolar point were derived. The absorption coefficient for 8-13 μ was determined, using data on temperature and energy flux. Comparison of the measurements with the results obtained by other authors for the region $\lambda = 0.8-2 \mu$ allows the derivation of spectral properties of the lunar surface in the wide spectral region 0.8-13 μ . The data obtained from the earth through the transparency windows of the atmosphere permit only a rough picture without any details. The absorption coefficient varies from $k \sim 0.9$ in 0.8-1.0 μ to the substantially lower value $k \sim 0.5$ for 3-4 μ and then rises again to 0.9-1.0 in the region of 8-13 μ . (Author)

A67-34140

THE SPECTROPHOTOMETRIC MEASUREMENTS OF THE MOON IN THE 1900-2750 Å RANGE FROM THE ZOND 3 AUTOMATIC SPACE PROBE.

A. I. Lebedinskii, V. A. Krasnopol'skii, and A. A. Krysko (Akademiia Nauk SSSR, Moscow, USSR).

IN: MOON AND PLANETS; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 7TH, VIENNA, AUSTRIA, MAY 10-18, 1966, PAPERS.

Symposium sponsored by the Committee on Space Research and the International Astronomical Union.

Edited by A. Dollfus.

Amsterdam, North-Holland Publishing Co., 1967, p. 59-64. 7 refs.

Fifteen spectra of the lunar surface have been measured from the Zond 3 automatic space probe in the 1900-2750 Å range with the resolution of 15 Å. The obtained spectra are similar in their structure to the solar spectrum, but different from this spectrum by somewhat unlike general dependence of the intensity. The lunar albedo curve calculated by means of averaging all the spectra is presented. The lunar albedo reaches the maximum of ~2% at about 2400 Å and decreases gradually to ~1% at 2000 and at 2700 Å. Some minute details are found on the background of this main regularity.

(Author)

A67-34141

THE LUNAR ULTRAVIOLET SPECTRUM IN THE RANGE OF 2850-3550 Å ACCORDING TO THE DATA OBTAINED FROM THE ZOND 3 AUTOMATIC SPACE PROBE.

A. I. Lebedinskii, G. M. Aleshin, V. A. Iozenas, V. A. Krasnopol'skii, A. S. Selivanov, and V. V. Zasetskii (Akademiia Nauk SSSR, Moscow, USSR).

IN: MOON AND PLANETS; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 7TH, VIENNA, AUSTRIA, MAY 10-18, 1966, PAPERS. Symposium sponsored by the Committee on Space Research and the International Astronomical Union.

Edited by A. Dollfus.

Amsterdam, North-Holland Publishing Co., 1967, p. 65-70.

Description of the ultraviolet spectra of the lunar surface which were photographed in the 2850- to 3550-Å range from the Zond 3 automatic space probe with a resolution of 13 Å. The spectrum images were treated and transmitted with the aid of a phototelevision device. The spectrograms make it possible to obtain the dependence of the lunar albedo on the average wavelength and also the local changes in the albedo. The dependence of the average lunar albedo is characterized by a decrease from about 4% at 3550 Å to about 3% at 3400 Å. In the interval of 3400 to 3100 Å, the lunar albedo depends only slightly on the wavelength, while in the 3100- to 2850-Å range a fairly steep decrease up to about 1% is observed.

P. v. T.

A67-34142

ON THE RADIOACTIVITY OF LUNAR ROCKS.

A. P. Vinogradov, Iu. A. Surkov, and L. P. Moskaleva.

IN: MOON AND PLANETS; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 7TH, VIENNA, AUSTRIA, MAY 10-18, 1966, PAPERS.

Symposium sponsored by the Committee on Space Research and the International Astronomical Union.

Edited by A. Dollfus.

Amsterdam, North-Holland Publishing Co., 1967, p. 71-82.

Discussion of the possibility of determining the content of the natural radioactive elements U, Th, and K in lunar rocks and of estimating the chemical composition of lunar rocks from cosmic-ray-induced radioactivity. The γ-radiation spectra of the natural isotopes and the spectra induced by cosmic rays in lunar rocks have been theoretically calculated and plotted. In experiments on an accelerator, the spectra of the γ-radiation arising during irradiation of various rocks with protons have been investigated. The spectra of the γ-radiation arising under the action of cosmic rays have been investigated on the satellite Cosmos 60. On the basis of theoretical calculations and experiments, it is shown that the chemical composition of lunar rocks may be estimated from the spectra of the γ-radiation induced by cosmic rays.

P. v. T.

A67-34143

MEASUREMENTS OF THE PENETRATING RADIATION INTENSITY ON THE MOON'S SURFACE.

S. N. Vernov, E. T. Gorchakov, Iu. I. Logachev, G. P. Liubimov, A. G. Nikolaev, N. V. Pereslegina, and P. V. Vakulov (Akademiia Nauk SSSR, Moscow, USSR).

IN: MOON AND PLANETS; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 7TH, VIENNA, AUSTRIA, MAY 10-18, 1966, PAPERS.

Symposium sponsored by the Committee on Space Research and the International Astronomical Union.

Edited by A. Dollfus.

Amsterdam, North-Holland Publishing Co., 1967, p. 83-87.

Presentation of experimental data obtained from the gas discharge counter installed on board the automatic station Luna 9. The radiation intensity during the transit of the station to the moon and that on the moon's surface are compared. The counting rate on the moon's surface is 26% in excess of half of that in space. The radioactivity of the moon's surface is evaluated, and a conclusion is drawn about the absence of the moon's radiation belts. (Author)

A67-34252 #

RECENT DEVELOPMENTS IN DETERMINATION OF THE LUNAR GRAVITATIONAL FIELD FROM SATELLITE ORBITS.

W. M. Kaula (California, University, Institute of Geophysics and Planetary Physics, Los Angeles, Calif.).

(British National Committee for Space Research, A Discussion on Orbital Analysis, International Meeting, London, England, Oct. 17, 18, 1966, Paper.)

Royal Society (London), Philosophical Transactions, Series A, vol. 262, July 13, 1967, p. 148-155. 18 refs.

Study of the variations in the lunar gravitational field, which are appreciably milder than those of the earth in the sense of stress-implication, indicating a state closer to hydrostatic equilibrium. The variations determined also have a considerable correlation with the lunar topography, indicating a shallower origin than the earth's variations. The data are still insufficient to determine firmly the lunar oblateness and thus help to resolve the problem of the moment of inertia of the moon.

F. R. L.

A67-34301

MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS.

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal (Manchester, University, Dept. of Astronomy, Manchester, England) and C. L. Goudas (Boeing Co., Boeing Scientific Research Laboratories, Mathematics Research Laboratory, Seattle, Wash.).

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967. 497 p. \$25.20.

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RECENT RESEARCHES ON THE DETERMINATION OF THE MOON'S PHYSICAL LIBRATION CONSTANTS.

Karol Kozieł (Kraków, Uniwersytet, Zakład Astronomji Teoretycznej i Geofizyki Astronomicznej and Obserwatorium Astronomiczne, Kraków, Poland).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U. S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 3-11. 23 refs. Research supported by the Polska Akademia Nauk.

Determination of the moon's physical libration constants on the basis of 3282 observations carried out with a heliometer in 340 evenings, covering the period from 1877 to 1915. A system of constants of the libration, including the coordinates of crater Mösting A, were determined simultaneously with other constants of the moon's free libration in longitude in a homogeneous way. The reductions of the observations were carried out on the basis of a new method of adjustment of heliometric libration observations, and a strict proof of the uniqueness of the solution for f (the moon's mechanical ellipticity) is given. Existing discrepancies in results obtained by various authors are discussed critically. F. R. L.

A67-34305

THE MOON'S ROTATION CONSTANTS AND THE COORDINATES OF MÖSTING A FROM THE HELIOMETRIC OBSERVATIONS OF BANACHIEWICZ.

J. Mietelski (Kraków, Uniwersytet, Zakład Astronomji Teoretycznej i Geofizyki Astronomicznej and Obserwatorium Astronomiczne, Kraków, Poland).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U. S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 29-34. 15 refs.

Analysis of the observation studies of Banachiewicz to determine the constants of the physical libration and figure of the moon - i.e., its mechanical ellipticity, the mean radius of its disk, the inclination of its rotation axis to the axis of the ecliptic, and the coordinates of the crater Mösting A, which was observed with Bessel's method. Yakovkin's investigation is clarified, and an attempt is made to determine the amplitude and the phase of the free lunar libration in longitude. F. R. L.

A67-34308

PHOTOGRAPHIC TECHNIQUES FOR THE DETERMINATION OF THE MOON'S CONSTANTS OF ROTATION.

D. W. G. Arthur (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U. S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 52-62.

Contract No. AF 19(628)-4332.

Observation that the heliometer can be replaced by the long focus photographic refractor as a means of obtaining selenodetic measurements, provided that the problems of scale and orientation can be surmounted. The use of ordinary and sinusoidal star trails for the solution of these problems is outlined. The analysis of the measures can follow that of classical selenodesy, involving the lunar limb, but the lunar photograph permits a better approach. The selenodetic coordinates are referred to a visible point on the lunar surface as origin. F. R. L.

A67-34309

SELENODETTIC MEASUREMENTS - AN INTRODUCTION.

Jean Rösche (Paris, Université, Paris; Toulouse, Université, Observatoire du Pic du Midi, Bagnères-de-Bigorre, Hautes-Pyrénées, France).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U. S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 71-77.

Examination of the field of general observational methods applied in selenodesy to date, with an outline of the various methods which can be used to determine the shape of the selenoid. The different methods used to determine the absolute coordinates of a point on the surface of the moon are considered and divided into several groups according to whether the regions near the limb or near the center are treated. The profile of the moon can be studied when there is a solar eclipse, especially an annular eclipse, by comparing it with the profile of the sun. Methods more applicable to central regions of the moon are also considered. F. R. L.

A67-34311

A SELENODETTIC EVALUATION OF ELEVEN PARIS LUNAR PHOTOGRAPHS.

Mahlon S. Hunt (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Terrestrial Sciences Laboratory, Bedford, Mass.).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U. S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 89-127.

Contract No. AF 61(052)-524.

Use of 11 selected original photographic plates from the 1894-1909 Paris Observatory collection of lunar photographs to acquire 1304 selenodetic measurements of 77 lunar features. The rms residual of all measurements on all plates for the two investigators was 24 μ , and there was no correlation between feature diameters and their reproducibilities. Results are provided as direction cosines of all lunar features corrected for differential refraction. F. R. L.

A67-34315**THE USE OF THE 48-INCH SCHMIDT TELESCOPE FOR SELENODETTIC OBSERVATIONS.**

Albert G. Wilson and Donna S. Wilson (McDonnell Douglas Corp., Advanced Research Laboratories, Huntington Beach, Calif.).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODETTIC AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 176, 177.

Investigation of the feasibility of using the 48-in. Palomar Schmidt telescope as a moon-star camera. The results obtained were highly unpromising. It was not possible to record the lunar surface and stars on the same plate. The intense brightness of the sky in the neighborhood of the moon, although the transparency was good, vitiated the attempt. The conclusion of the experiment was that the Schmidt is not useful as a moon camera without extensive and expensive modifications. While it may be possible to adapt the Schmidt for simultaneous moon-star field photography by inserting diaphragms, building a system of dual shutters, introducing suitable combinations of filters, and installing a declination-rate drive, none of this seems worthwhile. M. M.

A67-34318**HARMONIC ANALYSIS OF THE MOON'S SHAPE AND GRAVITATIONAL FIELD.**

C. L. Goudas (Boeing Co., Boeing Scientific Research Laboratories, Mathematics Research Laboratory, Seattle, Wash.).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODETTIC AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 237-281. 25 refs.

Detailed studies of the existing control systems for determining the moon's shape and comparison of the results obtained from each one with the expected values for the second zonal harmonic show that all systems leave something to be desired in accuracy. Out of them, the ACIC (1965) system can be said with certainty to be closer to the required accuracy, whereas the quality of the new (1966) system has definitely dropped. The quality of the new system by Schrutka-Rechtenstamm (1966) is low if compared with his earlier system (1958). This seems to be due to the unsuitable photography used. The gravity zonal coefficients computed here can be wrong only if the data are not accurate enough or if the moon is not sufficiently of uniform density - the former being a stronger reason than the latter. The tesseral and sectorial harmonics of both the figure and gravity field are affected by the assumption of symmetry, which can be true only to a small extent, and then not for all the harmonics. The preliminary Lunar Orbiter data have already indicated (Michael et al., 1966) that the symmetry assumption is reasonable for zonal harmonics. This is not entirely true for the others. (Author)

A67-34319**WHAT CAN WE SAY ABOUT THE SHAPE OF THE MOON?**

J. Hopmann (Wien, Universität, Universitäts-Sternwarte, Vienna, Austria).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODETTIC AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 282-294. 27 refs.

Discussion of seven principal series of observations of the exact shape of the moon. A comparison reveals, on the one hand, systematic amounts by which to reduce the altitude data to a common level, and, on the other hand, values of the absolute accuracy which amounts to approximately ± 1.1 km for three series, and to approximately ± 1.8 km for the others. The causes of the various differences are investigated. Plans are disclosed for the compilation of a preliminary general catalog of absolute heights on the moon. At the present stage of preliminary studies, it is expected to be able to list approximately 410 certain and 600 less reliable heights. The drawing of a contour map is also planned. Various attempts to represent the shape of the moon by a triaxial ellipsoid or by a series of spherical harmonics are discussed. It is pointed out that it seems more appropriate to regard the moon as a sphere covered with extended bulges and craters. M. M.

A67-34320**OBSERVATIONAL UNCERTAINTIES IN LUNAR CONTROL SYSTEMS.**

Donald L. Meyer (USAF, Aeronautical Chart and Information Center, St. Louis, Mo.).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODETTIC AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 295-304.

Discussion of elements which adversely affect a fundamental lunar-control solution. Primary consideration is given to those distortions in the observations that have magnitudes greater than the desired increment of detection. Displacements in the recorded image due to atmospheric distortion are analyzed, and methods of minimizing this effect through the use of sequential and long-exposure photographs are discussed. M. M.

A67-34322**THE MANCHESTER SELENODETTIC CONTROL SYSTEM.**

G. A. Mills and M. E. Davidson (Manchester, University, Dept. of Astronomy, Manchester, England).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODETTIC AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 317-331. 7 refs. Grant No. AF EOAR 64-49.

Two methods for determining absolute lunar coordinates, both based on the so-called "stereoscopic method," are discussed. The first method is dependent on determining the apparent coordinates of points on the lunar disk from photographs taken at different librations, which are eventually combined to form absolute coordinates. The second process makes no use of prior determinations of absolute heights. The organization of the measuring and reduction processes is also discussed. (Author)

A67-34323**THE LPL PROGRAM FOR SELENODETTIC POSITIONS - RESULTS AND COMPARISON WITH CONTEMPORARY SELENODETTIC WORK.**

D. W. G. Arthur (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODETTIC AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

A67-34324

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 332-340. 11 refs.

Discussion of the precision of the Lunar Planetary Laboratory selenodetic measurements in the context of existing selenodetic triangulations. Attention is drawn to the possibility of appreciable errors in the fundamental and secondary positions and to systematic errors of unknown origin in the photographic measures. M.M.

A67-34324 *

ESTIMATE OF FOUR TOPOCENTRIC LUNAR RADII.

W. L. Sjogren (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 341-343.

Determination of estimates of the dynamical center from four lunar surface points by means of tracking of four Ranger lunar probes by three earth-based stations. These stations obtained accurate recordings of impact times and also range rate measurements for many hours prior to and within seconds of impact. The range data determined the orbit relative to the triaxial moon and the recording of impact time triggered the proper radius vector. Comparisons of the Ranger tracking data results with the Army Maps and ACIC charts are tabulated. A consistent decrease of approximately 2.5 km from ACIC charts and some inconsistency with Army Maps are shown. M.M.

A67-34328

PHOTOMETRIC METHODS FOR DETERMINATION OF LUNAR RELIEF.

M. G. J. Minnaert (Utrecht, Rijksuniversiteit, Sterrewacht Sonnenborgh, Utrecht, Netherlands).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 383-395. 19 refs.

Evaluation of the possibility of using photometric methods to determine the relief of the lunar surface. The great advantage of the photometric method is that it permits a determination of the surface relief even from a single photograph. The complete results become more reliable if one or two other records are available, taken at considerably different phases. It is noted that the photometric method is applicable practically only up to a distance of approximately 40° longitude from the terminator. M.M.

A67-34329 *

SELENODESY FOR THE APOLLO PROJECT.

James H. Sasser (NASA, Manned Spacecraft Center, Space Science Div., Houston, Tex.).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 396-406. 11 refs.

Review of the Apollo lunar-landing mission. Areas in which lunar geodetic, cartographic, and topographic information is currently deficient are indicated. Established programs to correct these deficiencies are described. Slope- and protuberance-frequency information at the scale of a few meters is given for areas near the impact points of Rangers 7 and 8. These data are compared with the predicted roughness of an average lunar mare. Results indicate a rougher mare surface than previously anticipated. M.M.

A67-34330

TERMINATOR PHOTOGRAPHY IN OBLIQUE ILLUMINATION FOR LUNAR TOPOGRAPHIC WORK.

Zdeněk Kopal (Manchester, University, Dept. of Astronomy, Manchester, England).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 407-413.

Contract No. AF 61(052)-829.

Advantages to lunar topography of ground-based photographs taken under oblique illumination - especially in the penumbral zone of the lunar surface illuminated by the only partly risen sun - are discussed. It is pointed out that such photographs require, in general, exposure times from 10 to 100 times longer than would be conventionally regarded as "normal" and advantages of such "over-exposed" cine photography in minimizing by rapid projection the film-grain noise are stressed. Illustrative examples of such photography underline the advantages of this method. In particular, a comparison of two photographs of the crater Ptolemy - one taken with the 43-in. reflector of the Observatoire du Pic-du-Midi, the other with the FB camera of Ranger 9 from an altitude of 1406 km above the lunar surface - discloses that while the linear resolution of the Ranger camera at this altitude exceeds that of the 43-in. telescope more than 10 times, the vertical resolution of the ground-based but oblique-illumination photograph exceeds that secured from the Ranger to an almost equal extent. It is pointed out that photographs taken from terrestrial observatories of the lunar surface illuminated by the partly risen sun can furnish vertical relief data that are generally unobtainable from spacecraft unless the latter, while overflying the terminator, can secure sufficiently short exposures at the light level prevailing in the penumbral zone. (Author)

A67-34332

HIGH-RESOLUTION LUNAR PHOTOGRAPHY.

P. V. Sudbury (Manchester, University, Dept. of Astronomy, Manchester, England).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 424-432. Grant No. AF EOAR 64-49.

Discussion of recent improvements in the resolution of earth-based lunar photography. Procedures for the assessment of photography and its contribution to the lunar-mapping program are outlined. The requirements for a high-resolution lunar camera for the f/15 Cassegrain focus are listed, and the resolutions and film speeds of some Kodak emulsions are tabulated, together with the combination of image scales and emulsions that have achieved resolutions close to $0''.2$. It is pointed out that, in spite of the ap-

parent desirability of reducing exposure times to lessen the effects of image movements during photography, it seems certain that the best lunar photography has been taken with exposures in excess of 1 sec.

M.M.

A67-34333**ISODENSITOMETRIC AIDS TO LUNAR CHARTING.**

M. T. Jones (Manchester, University, Dept. of Astronomy, Manchester, England).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 433-450.

Grant No. AF EOAR 64-49.

Two possible applications of the recently developed Technical Operations Isodensitracer to lunar charting are discussed. The first is the determination of the selenocentric coordinates of photographed lunar features requiring densitometric analysis, with particular reference to relative altitude determinations through the medium of the shadow-projection method, and the second is the charting, by photometric methods, of lunar regions registered on photometrically controlled photographic images obtained from spacecraft based camera systems, with particular reference to the Orbiter series of space stations.

(Author)

A67-34334**DETERMINATION OF THE MOON'S SHAPE BY THE PHOTOMETRY OF ITS TERMINATOR.**

Odile Calame (Paris, Université, Faculté des Sciences, Paris; Toulouse, Université, Observatoire du Pic du Midi, Bagnères-de-Bigorre, Hautes-Pyrénées, France).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 451-454.

Discussion of a method for determining the moon's shape which goes back, in its rudimentary form, to Ritter (1927). The method is based on the fact that the geometrical shape of the terminator depends on that of the lunar globe. The instrument used for obtaining the lunar photographs was the refractor of 38-cm free aperture and total length of approximately 6 m at the Pic-du-Midi Observatory. One problem was to photograph the instantaneous position of the true terminator. Photographic plates used for this purpose were uniformly pre-exposed, and it was found that, on pre-exposed plates, the form of the terminator is no longer dependent on exposure time, by virtue of the compensation for the sensitivity threshold. It is noted that the method of terminator tracing should be primarily applicable to hypsometric studies of flatlands (maria), and may lead to their absolute height determination.

M.M.

A67-34335**ISODENSITOMETRIC MEASUREMENTS OF LUNAR SLOPES FROM THE RANGER PHOTOGRAPHS.**

A. Rifaat (Manchester, University, Dept. of Astronomy, Manchester, England).

IN: MEASURE OF THE MOON; INTERNATIONAL CONFERENCE ON SELENODESY AND LUNAR TOPOGRAPHY, 2ND, UNIVERSITY OF MANCHESTER, MANCHESTER, ENGLAND, MAY 30-JUNE 4, 1966, PROCEEDINGS. [A67-34301 18-30]

Conference sponsored by the Department of Astronomy of the University of Manchester and the Cambridge Research Laboratories of the U.S. Air Force.

Edited by Zdeněk Kopal and C. L. Goudas.

Dordrecht, Netherlands, D. Reidel Publishing Co. (Astrophysics and Space Science Library. Volume 8), 1967, p. 455-462.

Photometric measurement of elevation profiles for seven fields of the moon photographed in March 1965 by Ranger 9. Particular areas recorded by Ranger 9 were selected for photometric analysis performed with the aid of an isodensitracer developed by Joyce Loeb and Technical Operations. Typical isodensitometric transcripts of direct photographs are shown, together with the optimum parameters used in obtaining such records. The spot height, which was adjusted to reduce film graininess without integrating over too large a surface element, equals the slit height times the magnification of the objective. The discrete density increment is equal to the gray wedge length per commutator division in centimeters times the density (per cm) of the individual gray wedge. The reductions of the photometric measure for hypsometric profiles of the selected regions are under way.

M.M.

A67-34497 • #**RECONNAISSANCE OF INFRARED EMISSION FROM THE LUNAR NIGHTTIME SURFACE.**

Robert L. Willey (California Institute of Technology, Div. of Geological Sciences; Carnegie Institution of Washington and California Institute of Technology, Mount Wilson and Palomar Observatories, Pasadena, Calif.), Bruce C. Murray, and James A. Westphal (California Institute of Technology, Div. of Geological Sciences, Pasadena, Calif.).

Journal of Geophysical Research, vol. 72, July 15, 1967, p. 3743-3749, 8 refs.

Grant No. NSG-56-60.

Results of observations in the 8 to 14- μ wavelength region of the thermal emission from the lunar nighttime surface. The investigation was intended to sample representatively enough of the lunar surface to determine the general character of the lunar nighttime emission and the relative abundance of nighttime IR anomalies. The observational procedure is described in detail. Data are listed in tabular form for nearly all anomalous IR emission features recognizable on scans of Aug. 28, 29, and 30, 1964. The location of these anomalies on the lunar surface is indicated by a map. Approximately one-third to three-quarters of the lunar surface was sampled on each of three nights. A brief interpretation of some of the data is included.

T.M.

A67-34534**THE CONSTANTS OF THE MOON'S PHYSICAL LIBRATION DERIVED ON THE BASIS OF FOUR SERIES OF HELIOMETRIC OBSERVATIONS FROM THE YEARS 1877 TO 1915.**

Karol Koziel (Kraków, Uniwersytet, Zakład Astronomii Teoretycznej i Geofizyki Astronomicznej, Kraków, Poland).

Icarus, vol. 7, July 1967, p. 1-28, 29 refs.

Description of a new method for adjusting heliometric libration observations of the moon. On the basis of 3282 observations of the moon carried out in four heliometric series from the years 1877 to 1915, the forced libration constants are determined simultaneously with those of free libration in longitude by using the new method of adjustment of heliometric observations. The joint adjustment is performed by eliminating the moon's mean radius corresponding to each series, as it might be affected by irradiation. An exact proof is given for the uniqueness of the solution for the mechanical ellipticity of the moon; this ellipticity lies below the critical value 0.662. New values for the differences of the moon's principal moments of inertia are derived from the obtained libration constants. The coordinates of the crater Mösting A, which constitutes a first-order point of triangulation on the moon, are determined with high accuracy. The method is mathematically simple, satisfies the principles of the least-squares method, and is easily applicable to electronic computers.

T.M.

A67-34535 ***OPERATION MOON BLINK AND REPORT OF OBSERVATIONS OF LUNAR TRANSIENT PHENOMENA.**

Winifred Sawtell Cameron (NASA, Goddard Space Flight Center, Greenbelt, Md.) and John J. Gilheany (Trident Engineering Associates, Inc.; U.S. Naval Academy, Annapolis, Md.).

Icarus, vol. 7, July 1967, p. 29-41, 16 refs.

A67-34537

Demonstration of the ability of a blink technique (Moon Blink), analogous to the astronomical one used to detect motions of celestial objects, to detect red or blue temporary lunar phenomena. Twelve devices are in use in U.S. and two in England. NASA has organized a supplementary network of observers to confirm the Moon Blink observations and to report all types of transient lunar phenomena to a data collection center at Goddard Space Flight Center. Observations covering one and one-half years of the programs are analyzed and discussed in connection with various theories for the causes of these phenomena. F.R.L.

A67-34537

INFRARED IMAGES - IMPLICATIONS FOR THE LUNAR SURFACE.
John W. Salisbury and Graham R. Hunt (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Bedford, Mass.).

Icarus, vol. 7, July 1967, p. 47-58. 26 refs.

An IR image of the moon with the highest spatial resolution yet obtained is presented and compared to visible images and other IR images. The value of a radiance difference enhancement technique in the detection and study of brightness temperature anomalies is demonstrated. The characteristics of brightness temperature anomalies are reviewed. It is suggested that more than one type of anomaly may be present on the lunar surface and that large areas of apparent enhanced thermal emission during eclipses may be due to micrometeoroid "etching" of the surface layer. (Author)

A67-34538

SECONDARY VOLCANIC IMPACT CRATERS AT KAPOHO, HAWAII AND COMPARISONS WITH THE LUNAR SURFACE.

William K. Hartmann (Arizona, University, Lunar and Planetary Laboratory, and Dept. of Geology, Tucson, Ariz.).

Icarus, vol. 7, July 1967, p. 66-75. 7 refs.

NSF-supported research.

Craters formed by impacts of volcanic ejecta were studied both on aerial photographs and on the ground. The following relations are determined: (1) frequency distribution of crater diameters, (2) mass-diameter relation, and, from these, (3) frequency distribution of volcano ejecta masses. The latter differs from that found among lunar surface fragments (Surveyor 1), which resembles that caused by simple low-energy fragmentation; it is closer to that caused by repeated, multiple fragmentation. Mass distributions of other classes of objects are briefly discussed. The terrain of the Kapoho craters superficially resembles the lunar landscape. At metric dimensions on the lunar surface, simple fragmentation has acted, and secondary (meteoritic) craters similar to those at Kapoho may exist. (Author)

A67-34539

ESTIMATES OF THE ZONAL GRAVITY HARMONICS OF THE MOON.

T. A. Bray, C. L. Goudas, and Zdenka Kopal (Boeing Co., Boeing Scientific Research Laboratories, Seattle, Wash.).

Icarus, vol. 7, July 1967, p. 76-84. 10 refs.

The best figure data of the moon are treated in order to obtain estimates of the zonal gravity harmonics up to order eight. An analysis of the first tracking data of Lunar Orbiter 1 indicates that the second, third, and fourth zonal harmonics compare favorably with the values obtained on the basis of the figure, but there is no clue as to the reliability of the zonal harmonics given of order higher than the fourth. (Author)

A67-34545

NOTE ON THE NONUNIFORM COOLING BEHAVIOR OF THE ECLIPSED MOON.

R. F. Fudali (Smithsonian Institution, United States National Museum, Div. of Meteorites, Washington, D.C.).

Icarus, vol. 7, July 1967, p. 133-135.

Expansion of a previous discussion of lunar hot spots with reference to a criticism by Winter that the effect of surface roughness on the apparent temperature had not been considered. Arguments are adduced to demonstrate that surface geometry cannot be a significant factor in the production of lunar hot spots. F.R.L.

A67-34546

NOTE ON THE THERMAL HETEROGENEITY OF THE ECLIPSED MOON.

D. F. Winter (Boeing Co., Boeing Scientific Research Laboratories, Seattle, Wash.; Manchester, University, Dept. of Astronomy, Manchester, England).

Icarus, vol. 7, July 1967, p. 135-138. 9 refs.

Clarification of results of IR observations of the moon during a lunar eclipse, which revealed that hundreds of localized areas of the surface exhibit slower cooling rates than their environs. A re-statement is given of the difference between Fudali's hypothesis that thermal anomalies are caused by the absence of insulating debris and Winter's hypothesis which suggested that preferential surface roughness could play a role in producing anomalously high brightness temperatures. Various mechanisms are discussed which might contribute to the anomalous cooling of the eclipsed moon. F.R.L.

A67-35179 *

SCIENTIFIC RESULTS OF THE SURVEYOR I LUNAR LANDING.

Leonard D. Jaffe (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

COSPAR, Plenary Meeting, 10th, London, England, July 24-29, 1967, Paper, 39 p. 14 refs.

Observation that a surface layer basically similar to that at the Surveyor 1 site presumably covers much of the moon. Surveyor 1 landed in a mare area, about 100 m from a crater 170 m in diameter. The surface at this site consists mostly of discrete particles smaller than 100 μ . The density of this material near the surface is probably 0.9 g/cm³ or less, the cohesion is between 10² and 10⁵ dyne/cm², and the bearing strength is about 3 x 10⁵ dyne/cm². The granular layer is at least 1 m deep. Rocks in sizes up to a meter or more are abundant, many of them concentrated along crater rims. Some of these rock concentrations are apparently associated with local increases in radar cross section at 2-cm wavelength. The thermal and electromagnetic properties at the landing site, on a scale of a few meters, and the photometric function, on a scale down to millimeters, are similar to the gross properties of the entire lunar disk. (Author)

A67-35258

GAMMA INVESTIGATION OF THE MOON AND COMPOSITION OF THE LUNAR ROCKS.

A. P. Vinogradov, Iu. A. Surkov, G. M. Chernov, F. F. Kirnozov, and G. B. Nazarkina.

COSPAR, Plenary Meeting, 10th, London, England, July 24-29, 1967, Paper, 25 p. 27 refs.

Results of a gamma-ray investigation of lunar rocks carried out for the purpose of evaluating their chemical composition and radioactivity. The measurements of gamma rays were performed from the satellite orbit by cosmic station Luna 10. The main characteristics of the gamma spectra measured by Luna 10 are the exponential decrease in the gamma-ray intensity in the energy range up to 1.5 Mev and a certain reduction in the intensity at higher energy. The average radiation intensity was about 30 to 40%, while the intensity of the gamma background was about 60 to 70%. A comparison of the gamma spectra obtained with the calibration spectra of potassium, thorium, and uranium standards and with the spectra of terrestrial rocks permitted the relative contents of radioactive elements in the lunar rock to be estimated. The values obtained indicate that there exist on the moon rocks of basaltic and ultrabasic (dunitic and chondritic) composition. R.B.S.

A67-35263

LUNAR RADIUS FROM RADAR MEASUREMENTS.

A. Shapiro, E. A. Uliana, B. S. Yaplee, and S. H. Knowles (U.S. Navy, Office of Naval Research, Naval Research Laboratory, E. O. Hulburt Center for Space Research, Washington, D.C.).

COSPAR, Plenary Meeting, 10th, London, England, July 24-29, 1967, Paper, 24 p. 13 refs.

Determination of the lunar radius facing the earth from data collected by Lunar Orbiters 1 and 2. The variations of the radar values of the lunar radius agree with the local topography, but differences of 500 m to 1 km are found in widely separated areas. The lunar radius in the subearth region varies between 1736.28 km near M30 to 1739.58 km near Herschel, with a mean value for all areas of 1737.81 km. When the radar values are combined with the

Lunar Orbiter values along the equator, a bulge is found in the central region amounting to 1.5 km in the flat lands and 4.5 km in the mountains near Rhaeticus B. The extrapolated mean lunar radius is about 1 to 2 km below the presently accepted value of 1738.00 km. The technique described could be fully utilized by placing a radar system on an orbiting spacecraft around the moon and measuring the height of the satellite above the lunar surface. This would provide a complete description of the geometrical size and shape of the moon.

R.B.S.

A67-35266 * #**THE FIRST FOUR LUNAR ORBITER PHOTOGRAPHIC MISSIONS.**

Lee R. Scherer (NASA, Office of Space Science and Applications, Washington, D.C.).

COSPAR, Plenary Meeting, 10th, London, England, July 24-29, 1967,

Paper. 41 p. 5 refs.

Discussion of the first four Lunar Orbiter missions with respect to mission goals and design, and construction of the spacecraft and equipment, and examination of numerous photographs of the surface of the moon. The Surveyor/Orbiter team concept is briefly investigated and is illustrated by a correlation of the Surveyor and Orbiter pictures taken of the same area on the moon.

R.B.S.

A67-35275 #**INVESTIGATIONS OF SOLID INTERPLANETARY MATTER IN THE VICINITY OF THE MOON.**

T. N. Nazarova, A. K. Rybakov, and G. D. Komissarov.

COSPAR, Plenary Meeting, 10th, London, England, July 24-29,

1967, Paper. 10 p.

Investigation of interplanetary material by the Luna 10 satellite, carried out by means of piezoelectric sensors glued to the satellite skin and sensitive to the impacts of meteoritic particles with masses of 7×10^{-8} g and larger traveling at a velocity assumed to be 15 km/sec. Recorded particles were observed at heights from 355 to 1050 km and formed condensations varying in extent from 100 to 900 km. The impact rate recorded per unit time as a function of the distance from the moon is given, as well as the projection to the lunar surface of the satellite-trajectory portions at which particle impacts were recorded. A hypothesis for the increased density of matter in the vicinity of the moon is presented.

R.B.S.

A67-35308**STUDIES OF THE UPPER ATMOSPHERE AND OUTER SPACE CARRIED OUT IN THE USSR IN 1966.**

COSPAR, Plenary Meeting, 10th, London, England, July 24-29,

1967, Paper. 204 p. 545 refs.

Summary of findings made in the upper atmosphere, on the moon's surface, and in outer space from 1964 to 1966 by Soviet spacecraft. The world magnetic survey program performed during 1964 by the Cosmos 26 and 49 vehicles is discussed, and a description is given of findings made in the upper atmosphere, in space, and on the moon's surface by the Soviet Luna 9 to 13 space vehicles, launched in 1966. The measurement of the electron concentration and temperature in the upper atmosphere during 1966 is discussed, and the use of 191 meteorological rockets to determine the pressure and temperature of the earth's atmosphere and the direction and velocity of winds at heights up to 60 km is reviewed. The visual, photographic, and photometric observations of space vehicles by 61 visual and 25 photographic stations during 1966 are described, and the application of outer space for telecommunication, using the satellite Molniia (launched in 1965), is detailed.

B.B.

A67-35322 * #**A PHOTOMETRIC TECHNIQUE FOR DERIVING SLOPES FROM LUNAR ORBITER PHOTOGRAPHY.**

J. J. Lambiotte and G. R. Taylor (NASA, Langley Research Center, Hampton, Va.).

American Astronautical Society and New England Academic Community, Regional Symposium on Planetary Geology and Geophysics, Boston, Mass., May 25-27, 1967, Paper. 23 p. 11 refs.

To aid in the preliminary evaluation of lunar orbiter data at the Langley Research Center, a computer program and associated technique was developed to derive relative roughness values for the

lunar surface from monoscopic high resolution data by photoclinometry. This technique relates measured scene brightness, spacecraft geometry, and a lunar photometric function to determine slope values. In this way hundreds of thousands of slopes have been computed. The paper includes a brief discussion of the photometric model and computer program used, the steps taken to provide necessary calibrations and inputs to the program, and examples of results from the early missions. Also included is an analysis of the validity of the results obtained.

(Author)

A67-35328 #**CONCEPTUAL DESIGN FOR AN ACTIVE SEISMIC EXPERIMENT FOR THE LUNAR SURFACE.**

A. Baker, V. Head, and G. Richards (Radio Corporation of America, Princeton, N.J.).

American Astronautical Society and New England Academic Community, Regional Symposium on Planetary Geology and Geophysics, Boston, Mass., May 25-27, 1967, Paper. 59 p. 7 refs.

Review of the principles of active seismology and of some practical problems associated with the derivation of travel-time curves, the results being used to generate a conceptual design of an active seismic experiment for lunar surface missions. Four basic communications approaches are investigated. A tradeoff analysis indicates the advantages and disadvantages of each in terms of complexity and equipment required; the real-time analog approach is found to be the best approach.

B.B.

A67-35644 ***SPACE EXPERIMENTS PROGRAM FOR PRACTICAL APPLICATIONS.**

Willis B. Foster (NASA, Office of Space Science and Applications, Washington, D.C.).

IN: PRACTICAL SPACE APPLICATIONS; AMERICAN ASTRONAUTICAL SOCIETY, NATIONAL MEETING, SAN DIEGO, CALIF., FEBRUARY 21-23, 1966, PROCEEDINGS.

Edited by L. L. Kavanau.

Washington, American Astronautical Society, Inc.; Sun Valley, Calif., Scholarly Publications, Inc. (Advances in the Astronautical Sciences. Volume 21), 1967, p. 153-170.

Demonstration, through the Apollo program, that man can operate in cislunar space and on the lunar surface. It is imperative to be prepared to take full advantage of this capability in applying it to the benefit of all mankind. Significant progress has been made in the application of space technology in the field of agriculture, forestry, meteorology, oceanography, and geology; even more will be done in these areas as the capabilities of the manned program are developed even further in the post-Apollo period.

P.v.T.

A67-35830 #**GEOLOGICAL INTERPRETATION OF MOON-PROBE PHOTOGRAPHS [SONDEN-MONDPHOTOS IN GEOLOGISCHER SICHT].**

Kurd von Bülow.

Weltraumfahrt Raketentechnik, vol. 18. Mar.-Apr. 1967, p. 37-44. In German.

Study of the moon-probe photographs in order to ascertain the material and structural condition of the surface rocks of the moon and their "carrying capacity" for future landings on the moon. The problems of the degree of disintegration of lunar rocks and the existence of a dust layer on the lunar surface are discussed. Pictures taken by American and Soviet moon probes of the Ranger, Surveyor, and Luna types are reproduced and interpreted. Concerning the genesis of the crust of the moon, it seems now beyond doubt that most of the lunar surface formations are of a magnetic and volcanic origin.

P.v.T.

A67-35894**RANGER VIII AND GRAVITY SCALING OF LUNAR CRATERS.**

Ralph B. Baldwin (Oliver Machinery Co., Grand Rapids, Mich.).

Science, vol. 157, Aug. 4, 1967, p. 546, 547. 8 refs.

Discussion of the crater-forming process on the moon from the impact of Ranger 8, and ascertainment of the existence of gravity scaling. It is noted that it appears highly probable that the C₂ crater is the one produced by Ranger 8. This crater is 13 m in diameter, in such close agreement with the fourth-root gravity scaling that the latter is probably correct. If fourth-root

A67-35942

gravity scaling is correct, it implies that the outer layers of the moon's surface are composed of materials whose cohesiveness is close to that of terrestrial soils, much as Surveyor 3 has shown them to be. The results of Moraski et al. would appear not to apply to the Ranger 8 crater. M.M.

A67-35942 *

THE EFFECT OF LUNAR TERRAIN UNCERTAINTIES ON KALMAN FILTER PERFORMANCE DURING THE LUNAR LANDING POWERED DESCENT.

H. Lee Tucker, Jr. (Grumman Aircraft Engineering Corp., Guidance and Control Dept., Bethpage, N.Y.).

American Institute of Aeronautics and Astronautics, Guidance, Control and Flight Dynamics Conference, Huntsville, Ala., Aug. 14-16, 1967, Paper 67-543. 9 p.

Members, \$0.75; nonmembers, \$1.50.

A study of the estimation and optimization of trajectory states during the powered-descent portion of the lunar landing mission is presented. The estimates are based on landing-radar-derived range and velocity data and the trajectory state's inertial-guidance-system indications. The optimization, which uses Kalman filtering techniques, required that a method be derived to investigate the effects of time-correlated lunar terrain and measurement errors associated with the estimates. A time-correlated error is defined as an error which occurs during the interval that the measurements are taken. Lunar terrain errors result from uncertainties as to the mean lunar radius (constant bias errors) and lunar slopes (varying bias errors) near the landing site. The uncertainties are introduced through landing-radar range measurements, which are made relative to the lunar surface. A method by which to treat the effects of these errors on successive estimates is presented. It is shown that there is a decrease in the Kalman filter's effectiveness in reducing variances in estimated navigation parameters. The effects of the measurement uncertainties on correlation characteristics and the initial navigation covariance matrix are evaluated. Simplifications which may be made in the optimization equations are indicated. (Author)

A67-36598 *

LIGHTING CONDITIONS FOR A LUNAR LANDING MISSION.

Vladimir Hamza (Bellcomm, Inc., Washington, D.C.).

Naval Council of Technical Societies, Space Congress on the Challenge of the 1970's, 4th, Cocoa Beach, Fla., Apr. 3-6, 1967, Paper. 24 p. 9 refs.

Indication that for certain combinations of lighting and viewing conditions, the lunar landing site will be void of visible details because of the strong backscattering photometric properties of the lunar surface. To demonstrate this effect, photographs of a scale model of a lunar surface dusted with copper oxide under various lighting and viewing angles were made. Copper oxide was chosen because its reflection properties are similar to those of a lunar surface. Each picture is identified on the CuO photometric function chart. Those pictures showing good terrain detail correspond to the high-contrast region on the chart. It is shown that a substantial improvement of the astronaut's viewing conditions could be achieved with descent trajectories whose viewing angles are greater than the sun angles or trajectories in which the sun is off to one side.

P.v.T.

A67-36649 *

SURVEYOR I - LOCATION AND IDENTIFICATION

L. Harold Spradley (USAF, Aeronautical Chart and Information Center, St. Louis, Mo.), R. Steinbacher (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.), M. Grolier (U.S. Geological Survey, Flagstaff, Ariz.), and C. Byrne (Bellcomm, Inc., Washington, D.C.).

Science, vol. 157, Aug. 11, 1967, p. 681-684.

Outline of the location and identification of the Surveyor 1 spacecraft on the moon's surface by photographs taken by the Orbiter 3 spacecraft in Feb. 1967. Surveyor 1 was located on the photographs and all search and identification criteria were satisfied by the site. Since Orbiter's shadow could not be adequately characterized by visual examination of the photographs, they were scanned with a recording microdensitometer, which enabled examination of isophotometric patterns and gradients of image brightness below the limits of visual detection. B.B.

A67-36948

EVOLUTION OF THE MOON'S SURFACE. I.

E. J. Öpik (Armagh Observatory, Armagh, Northern Ireland; Maryland, University, College Park, Md.).

Irish Astronomical Journal, vol. 8, Mar.-June 1967, p. 38-52.

Summary of methods, results, and conclusions from a critical study of the evolution and present state of the lunar surface, based in particular on quantitative theories of cratering and planetary encounters. The present study leads essentially to conclusions previously reached, except that primitive plutonic activity seems to have been limited to partial melting caused by impacts, while true volcanic activity or lava effusions due to internal activity never have affected the presently observable lunar surface. Cratering and planetary encounters and the origin of the moon are treated.

F.R.L.

A67-36997

EXTRUSIVE LUNAR RING STRUCTURES?

William K. Hartmann (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).

Science, vol. 157, Aug. 18, 1967, p. 841.

Discussion of the argument by O'Keefe, Lowman, and Cameron (1967) that the curious morphology (convex profile, evidence of post-mare age, and patterned surface) of the slopes of the Flamsteed Ring hills indicates an extrusive flow structure. It is pointed out that the weakness of this argument lies in the fact that the curious morphology is not peculiar only to lunar craters similar to the Flamsteed Ring, but is found in the typical, bowl-shaped craters with sharp, raised rims, widely interpreted as impact explosion pits.

M.F.

A67-37470

COMMENTS ON THE IDENTIFICATION OF THE EMISSION FEATURE OBSERVED BY KOZYREV IN THE CRATER ALPHONSUS.

John G. Phillips (California, University, Dept. of Astronomy, Berkeley, Calif.) and Claude Arpigny (Liège, Université, Institut d'Astrophysique, Liège, Belgium).

Astrophysical Journal, vol. 149, Aug. 1967, pt. 1, p. 275-281.

6 refs.

Outline of the observational and theoretical difficulties associated with the suggestion that the emission observed in the crater Alphonsus by Koz'yrev is part of the Swan system of the C₂ molecule. It is pointed out that at the present time no alternative suggestion can be made.

R.B.S.

A67-37549

INTRODUCTION TO THE SCIENCE OF SELENODESY [WSTĘP DO STUDIUM SELENODEZJI].

Ludomław Cichowicz.

Geodezja i Kartografia, vol. 16, no. 3, 1967, p. 169-190. 10 refs. In Polish.

Review of available data associated with the lunar mass and its motion together with a description of contemporary methods for lunar studies. The lunar shape, dimensions, and mass are examined, and the distance of the moon from the earth - and several methods of determining this distance - are treated. The lunar orbit and its motion around the earth and about its axis are discussed. Methods of selenographic observation are reviewed including lunar occultations of stars, solar eclipses, Markowitz lunar cameras, satellite cameras, and the use of radar and lasers. The lunar magnitude, albedo, gray light, and atmosphere are described together with expected environmental conditions on the surface. Various aspects of selenodesy are discussed in terms of coordinates, spherical seleno-centric astronomy, and satellite observations. T.M.

A67-37838

INVESTIGATION OF LUNAR X-RAY EMISSION WITH THE HELP OF THE LUNAR SATELLITE LUNA-10.

S. L. Mandel'shtam, I. P. Tindo, and V. I. Karev.

(Kosmicheskie Issledovaniia, vol. 4, Nov.-Dec. 1966, p. 827-837.)

Cosmic Research, vol. 4, Nov.-Dec. 1966, p. 716-724. 12 refs. Translation.

A67-37840**MEASUREMENT OF CORPUSCULAR RADIATION ON THE SPACE PROBE LUNA-10.**

N. L. Grigorov, V. L. Maduev, N. F. Pisarenko, and I. A. Savenko. (*Kosmicheskie Issledovaniia*, vol. 4, Nov.-Dec. 1966, p. 842-850.) *Cosmic Research*, vol. 4, Nov.-Dec. 1966, p. 729-735. 5 refs. Translation.

A67-37846**CURRENT PROBLEMS IN THE MORPHOLOGY OF THE LUNAR SURFACE.**

Iu. N. Lipskii, Iu. P. Pskovskii, A. A. Gurshtein, V. V. Shevchenko, and M. M. Pospergelis.

(*Kosmicheskie Issledovaniia*, vol. 4, Nov.-Dec. 1966, p. 912-922.) *Cosmic Research*, vol. 4, Nov.-Dec. 1966, p. 784-793. 23 refs. Translation.

A67-37897**ISOLATING LUNAR MATERIALS.**

Gilbert Fielder (London, University, Observatory, Mill Hill, Middx., England).

Nature, vol. 215, Aug. 26, 1967, p. 944, 945.

Research supported by the Natural Environment Research Council.

Description of a new method of narrowing the choice of lunar-surface materials through an examination of the albedo, color, and polarization properties of submillimetric particles as a function of grain size. The method is illustrated by reference to certain physical studies of eleven basic and intermediate rocks ground to various grain sizes. Contrary to earlier findings, certain rocks in their natural, nonirradiated state are evidently possible candidates for a lunar surface model. M. F.

A67-38188 * #**LUNAR SURFACE ROUGHNESS - SHADOWING AND THERMAL EMISSION.**

Bruce G. Smith (Bellcomm, Inc., Washington, D.C.).

Journal of Geophysical Research, vol. 72, Aug. 15, 1967, p. 4059-4067. 13 refs.

NASA-supported research.

A statistical model of the moon's surface roughness is used in an attempt to explain the deviations of the observed gross infrared thermal emissive properties of the moon from those characterizing a smooth Lambertian surface. Comparison of theory and experiment suggests that the thermal brightness variation across the full moon disk is affected by large-scale relief of rms slope 10 to 20°. The method requires development of a self-shadowing theory of random rough surfaces, which can be used, in a different context, to determine local rms surface slope from the amount of shadow visible in a moon photograph. It is suggested that this technique may be particularly useful in the rapid analysis of Lunar Orbiter photography. Analysis of an earth-based photograph of a typical highland region yields 9° for the rms slope of large-scale roughness. The rms slopes deduced agree with those found in radar studies of the moon. (Author)

A67-38197 #**MAPPING OF THE MOON [O KARTOGRAFIROVANII LUNY].**

B. N. Rodionov.

(Moskovskii Institut Inzhenerov Geodezii, Aerofotos'emki i Kartografi, Nauchno-Tekhnicheskaiia Konferentsiia, Moscow, USSR, Apr. 12, 1966.)

Geodeziia i Kartografiia, July 1967, p. 39-45, 47. In Russian.

Survey of problems associated with lunar cartography accomplished with the aid of space vehicles. The mapping of the lunar surface by lunar satellites is discussed in terms of the optimal methods of information transmission to the earth and equipment necessary for this purpose. The power limitation of the transmitted signals makes it necessary to transmit at a slow rate in order to filter noise from the information. Three methods of transmission are described involving instant memorization of the image, slow

scanning by an electromechanical device, and memorization of the image by photography. The photography of the lunar surface is considered from the viewpoint of satellite orbits and motion. Problems associated with satellite coordinates and center of mass are examined. T.M.

A67-39119 ***MINERAL DEPOSITS ON THE MOON.**

George Mueller (Concepcion, Universidad, Concepcion, Chile; Miami, University, Institute of Molecular Evolution, Coral Gables, Fla.).

Nature, vol. 215, Sept. 9, 1967, p. 1149-1151. 10 refs.

NASA-supported research.

Assessment of the extent to which it is possible to reconstruct the mineral assemblage of the moon. Each genetic class of mineral deposits which might be expected to be found is briefly considered. Because of the probable basic character of much lunar rock, deposits produced by magmatic segregation (magnetite, pyrite, and chromite) are likely to occur. It seems likely that the moon is rich in fumarole products. As regards relatively low-temperature, deep-seated hydrothermal deposits, the moon is expected to be essentially an oceanic type of mineralogical province. It is unlikely that sedimentary and metamorphic deposits exist. As for carbonaceous deposits, it is suggested that the moon may have more carbon in its crust than the earth has. Impactites must be of greater importance on the lunar surface than on the earth. Economic exploitation of lunar minerals may be feasible if the cost of space travel can be reduced. F.R.L.

A67-39297 #**STRUCTURE OF LUNAR CRATERS AND CRATER FIELDS [O STRUKTURE LUNNYKH KRATEROV I KRATERNYKH POLEI].**

A. K. Mukhamedzhanov (Vsesoiuznyi Nauchno-Issledovatel'skii Institut Optiko-Fizicheskikh Izmerenii, USSR).

Astronomicheskii Vestnik, vol. 1, July-Sept. 1967, p. 158-167. 10 refs. In Russian.

Comparison of theoretical data concerning the impact formation of lunar craters with experimental measurements of distances between inner and outer rims of complex craters. The formation of both separate craters and crater fields in the vicinity of the lunar seas is examined in terms of theoretical and experimental conclusions. A method for determining the local density of the lunar surface is proposed using formulas for the shape of the crater in terms of impact velocity and density of the colliding bodies. Estimates are made of the density of certain parts of the lunar surface, and it is concluded that the density of the lunar cover increases with depth. T.M.

A67-39298 #**THE LUMINESCENCE OF THE LUNAR SURFACE [O LIUMINES-TSENTSII LUNNOI POVERKHNOSTI].**

N. N. Evsiukov (Khar'kovskii Gosudarstvennyi Universitet, Astronomicheskaiia Observatoriia, Kharkov, Ukrainian SSR).

Astronomicheskii Vestnik, vol. 1, July-Sept. 1967, p. 168-172. In Russian.

Determination of the luminescence of the lunar surface in the infrared (1000 mμ) and ultraviolet (370 mμ) bands. It is shown that luminescence within these wavelengths is present over the entire lunar surface and its brightness at full moon is 17% of the moon's brightness in the ultraviolet region and 6% in the infrared region. The distribution of the luminescence over the surface is studied, and it is determined that the brightness depends only on the angle of incidence of the solar rays. The nature of the luminoform is considered with the conclusion that the silicates are the source of the luminescence. The luminescent materials are most probably distributed at the bottom of surface irregularities. T.M.

A67-39309**RESULTS OF THE RANGER, LUNA 9, AND SURVEYOR 1 MISSIONS.**

Hans J. Behm (Grumman Aircraft Engineering Corp., Advanced Systems Dept., Bethpage, N.Y.).

Journal of the Astronautical Sciences, vol. 14, May-June 1967, p. 101-111. 15 refs.

A67-39977

Discussion of lunar surface geology in light of information obtained by the U.S. unmanned lunar missions, Ranger and Surveyor 1, as well as the Soviet mission Luna 9. Characteristics of the lunar terrain are analyzed including roughness, distribution of rubble, craters, slopes, fracture structures, and bearing strength. Previous predictions are refuted, modified, or confirmed, and new conclusions are reached. It is not meant as an attempt to settle the controversy regarding the origin and evolution of the surface features - i.e., craters, maria, and the highlands - but rather as an attempt to provide meaningful conclusions which will be useful in the vital selection of a manned lunar landing site. (Author)

A67-39977 **

ESTIMATED THICKNESS OF A FRAGMENTAL SURFACE LAYER OF OCEANUS PROCELLARUM.

Verne R. Oberbeck and William L. Quaide (NASA, Ames Research Center, Space Sciences Div., Moffett Field, Calif.). Journal of Geophysical Research, vol. 72, Sept. 15, 1967, p. 4697-4704. 8 refs.

Laboratory impact cratering studies have been used to analyze the relationship between the crater size and crater morphology observed on the Lunar Orbiter 1 photographs. The results indicate that the fragmental surface layer is of variable thickness in the area of the Surveyor 1 landing site on Oceanus Procellarum. It is estimated that in 85% of the area the fragmental cover is between 5 and 15 m thick. The estimated modal thickness is in the 5- to 6-m range, and the average thickness is from 8 to 9 m. Differences are indicated in the average thickness between this region and other mare regions and between the maria and the highlands photographed by Orbiter 1. Such differences could have an age significance, implying that new rock surfaces on the moon have been formed at different times. (Author)

A67-39980

ON THE TREATMENT OF RADIATIVE TRANSFER IN THE LUNAR DIURNAL HEAT FLOW.

Robert L. Wilder (U.S. Geological Survey, Center of Astrogeology, Flagstaff, Ariz.). Journal of Geophysical Research, vol. 72, Sept. 15, 1967, p. 4765-4767. 10 refs.

Brief examination of radiative transfer of the lunar surface in terms of heat-flow analysis. A geometric model of a porous medium studied by Watson (1964) is treated, and the additive term in the conductivity, proportional to the cube of the temperature of the model, is derived somewhat more generally by starting from two of the classical equations of stellar interiors. R. B. S

A67-40143 *

PREDICTING THE LUMINANCE OF THE LUNAR SURFACE.

Walter H. Rauser (Northrop Corp., Northrop Norair, Northrop Space Laboratories, Research and Analysis Section, Huntsville, Ala.).

IN: AMERICAN ASTRONAUTICAL SOCIETY, SOUTHEASTERN SYMPOSIUM ON MISSILES AND AEROSPACE VEHICLES SCIENCES, HUNTSVILLE, ALA., DECEMBER 5-7, 1966, PROCEEDINGS. VOLUME 2.

Symposium sponsored by the American Astronautical Society, the University of Alabama, NASA Marshall Space Flight Center, and the Missile Command of the U.S. Army. Huntsville, Ala., American Astronautical Society, Southeast Section, 1966, p. 61-1 to 61-12. 6 refs.

Contract No. NAS 8-20082.

Study of methods for predicting the luminance of a lunar surface site as seen by a local observer over a lunation. Both direct solar and earth-reflected illumination are considered, along with local albedo variations. A comparison is made of the following basic models of the lunar surface: (1) a uniformly diffusing surface; (2) a surface obeying a luminance factor obtained from earth-based observational data; and (3) a surface obeying an analytical photometric function derived from observational data. The uniformly diffusing surface model gives luminance values that vary with time but are independent of the observer's orientation. The luminance factor and photometric function models predict surface luminance values that vary with time, the observer's orientation, and his line

of sight. The strong backscattering characteristics of the last two models present viewing situations quite different from those found in the terrestrial environment. P.v.T.

A67-40144 *

POST-APOLLO LUNAR MISSION PLANNING.

E. Zaitzeff, O. L. Tiffany (Bendix Corp., Bendix Systems Div., Ann Arbor, Mich.), and J. Downey, III (NASA, Marshall Space Flight Center, Research Projects Laboratory, Scientific Payloads Branch, Huntsville, Ala.).

IN: AMERICAN ASTRONAUTICAL SOCIETY, SOUTHEASTERN SYMPOSIUM ON MISSILES AND AEROSPACE VEHICLES SCIENCES, HUNTSVILLE, ALA., DECEMBER 5-7, 1966, PROCEEDINGS. VOLUME 2.

Symposium sponsored by the American Astronautical Society, the University of Alabama, NASA Marshall Space Flight Center, and the Missile Command of the U.S. Army. Huntsville, Ala., American Astronautical Society, Southeast Section, 1966, p. 62-1 to 62-11.

Study of a mission planning for a post-Apollo period, including selection of typical lunar sites and definition of certain preferred experiments. The traverse (or sortie) experiments are considered. The major conclusion of the study is that an astronaut will be busy with various housekeeping and personal activities during the lunar exploration leaving a comparatively small amount of time for scientific activity. Within that scientific activity, he will be expected to perform loading, unloading, emplacement, and delivery tasks which may use up a large percentage of the total scientific time available. Greater emphasis should be placed on automatizing some of the geophysical instruments that can be operated while the vehicle is moving and allow the astronaut more time for scientific observation, geological mapping, and evaluation. P.v.T.

A67-40378

TELEVISION PICTURES OF THE LUNAR SURFACE BY EARTH-SHINE.

L. E. Blanchard (Hughes Aircraft Co., Aerospace Group, Space Systems Div., El Segundo, Calif.).

Society of Motion Picture and Television Engineers, Technical Conference, 102nd, Chicago, Ill., Sept. 17-22, 1967, Paper 102-40. 7 p.

Discussion of the effects of modifications made to the Surveyor spacecraft television camera to provide a light-integration capability (bulb mode), so that pictures of the lunar surface can be obtained with only the light reflected from the earth's disk as the illuminating source. The integration mode allows stars to be viewed down to magnitude 6, with a theoretical limit of magnitude 8. Another application is the detection of the extent of solar radiation of the solar corona at various radii from the edge of the solar disk after sunset. B. B

A67-40947

LUNAR VESICULATION PROCESSES AS RELATED TO LUNA AND SURVEYOR PROBE DATA.

E. Azmon (Northrop Corp., Northrop Norair, Northrop Space Laboratories, Hawthorne, Calif.).

IN: INTERPRETATION OF LUNAR PROBE DATA; AMERICAN ASTRONAUTICAL SOCIETY, SPECIALIST SYMPOSIUM, HUNTINGTON BEACH, CALIF., SEPTEMBER 17, 1966, PROCEEDINGS. Edited by Jack Green.

Tarzana, Calif., American Astronautical Society (AAS Science and Technology Series. Volume 14), 1967, p. 7-14; Discussion, Raoul Choate (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.) and N. M. Short (Houston, University, Houston, Tex.), p. 14, 15.

Discussion of experiments designed to determine the relation between the appearance of common silicate rocks and the physical conditions that govern their genesis - with particular emphasis on vesiculation processes. It is found that at a certain temperature for certain rocks, it is possible to develop vesiculation only after keeping the rock at this temperature for a particular length of time. It is thought that the rock photographed by a Surveyor camera on the surface of the moon can be identified as a vesicular, possibly

pumiceous, volcanic bomb. This identification implies the fairly recent existence of volcanic processes on the moon. M. F.

A67-40948

A REVIEW OF SHOCK PROCESSES PERTINENT TO FRAGMENTATION AND LITHIFICATION OF THE LUNAR TERRAIN.

Nicholas M. Short (Houston, University, Houston, Tex.).

IN: INTERPRETATION OF LUNAR PROBE DATA; AMERICAN ASTRONAUTICAL SOCIETY, SPECIALIST SYMPOSIUM, HUNTINGTON BEACH, CALIF., SEPTEMBER 17, 1966, PROCEEDINGS.

Edited by Jack Green.

Tarzana, Calif., American Astronautical Society (AAS Science and Technology Series. Volume 14), 1967, p. 17-60. 19 refs.

Compendium of information on shock processes that act on terrestrial and lunar rocks. Recent advances in identifying and characterizing shock effects and processes in rock materials are reviewed. Pertinent discoveries resulting from the current surge of studies of terrestrial impact craters are reported, and the relationship of shock processes and of terrestrial impact craters to the continuing studies of the lunar surface is examined, especially in the light of the Surveyor and Lunar Orbiter pictures. Emphasis is placed on specification of criteria that can be applied to lunar samples returned from Apollo missions in order to recognize the presence of shock effects in these materials. M. F.

A67-40949

COHESIVE PROPERTIES OF LUNAR SOILS AS INDICATED BY SURVEYOR ONE.

J. Ryan (McDonnell Douglas Corp., Douglas Aircraft Co., Missile and Space Systems Div., Santa Monica, Calif.).

IN: INTERPRETATION OF LUNAR PROBE DATA; AMERICAN ASTRONAUTICAL SOCIETY, SPECIALIST SYMPOSIUM, HUNTINGTON BEACH, CALIF., SEPTEMBER 17, 1966, PROCEEDINGS.

Edited by Jack Green.

Tarzana, Calif., American Astronautical Society (AAS Science and Technology Series. Volume 14), 1967, p. 61-76; Discussion, p. 76-80.

Discussion of processes proposed to act on the lunar materials to produce agglomeration and/or disruption. The processes considered include micrometeorite impact, sputtering, thermal fracturing, alkali metal vapor deposition, radiation damage with metamictization, sintering, electrostatic surface charging, and atomic adhesion. It is found that the range of adhesion phenomena which can occur on the moon is quite large, and that the exact role played by the adhesion depends critically on the nature of the contacting surfaces. The implications Surveyor gives as to which of these processes, if any, might act on the lunar surface are examined. It is pointed out that Surveyor has provided the first direct evidence that both disruptive and agglomerative processes are acting on the lunar surface, but it has not provided a unique solution as to which of the various proposed processes may dominate, and to what degree. M. F.

A67-40950

MECHANICAL, OPTICAL, THERMAL, AND ELECTRICAL PROPERTIES OF THE SURVEYOR 1 LANDING SITE.

John D. Halajian (Grumman Aircraft Engineering Corp., Bethpage, N. Y.).

IN: INTERPRETATION OF LUNAR PROBE DATA; AMERICAN ASTRONAUTICAL SOCIETY, SPECIALIST SYMPOSIUM, HUNTINGTON BEACH, CALIF., SEPTEMBER 17, 1966, PROCEEDINGS.

Edited by Jack Green.

Tarzana, Calif., American Astronautical Society (AAS Science and Technology Series. Volume 14), 1967, p. 81-108; Discussion, p. 109-112. 11 refs.

Surveyor 1 data are evaluated with particular emphasis on the soil mechanics of the landing site. A downward revision of the bulk density of the lunar surface material from a previously suggested value of 1.5 g/cm³ to about 1 g/cm³ is proposed on the basis of mechanical, thermal, photometric, and dielectric evidence. The revision indicates an aenderdense, partially consolidated material

that can be approximated on earth by snow or semiwelded tuffs.

The principles of conventional soil mechanics do not readily apply to the study of such materials. Further analysis of Surveyor 1 data and, particularly, coordination between astronomical and on-site measurements of the lunar surface are suggested to refine these estimates and increase the usefulness of future Surveyors.

(Author)

A67-40951

THE NATURE OF THE SURFACE OF THE MOON, ILLUSTRATED IN PART BY 3-D SLIDES TAKEN FROM RANGER PHOTOGRAPHS. D. H. Menzel (Smithsonian Institution, Smithsonian Astrophysical Observatory and Harvard University, Dept. of Astronomy, Harvard College Observatory, Cambridge, Mass.).

IN: INTERPRETATION OF LUNAR PROBE DATA; AMERICAN ASTRONAUTICAL SOCIETY, SPECIALIST SYMPOSIUM, HUNTINGTON BEACH, CALIF., SEPTEMBER 17, 1966, PROCEEDINGS.

Edited by Jack Green.

Tarzana, Calif., American Astronautical Society (AAS Science and Technology Series. Volume 14), 1967, p. 113-121; Discussion, Jack Green (McDonnell Douglas Corp., Douglas Aircraft Co., Advanced Research Laboratories, Huntington Beach, Calif.) and D. D. Hale (NASA, Marshall Space Flight Center, Research Projects Laboratory, Huntsville, Ala.), p. 122.

Discussion of possible explanations for the origin of scars and ghost craters on the lunar surface. An examination is made of the hypothesis that a large area, inundated with molten lava, broke away from the supporting crust and sank. The remaining scars resulted from the influence of the totally submerged formation upon the convective cooling of the lava, as it slowly solidified. M. F.

A67-40952

SELENO-GEOLOGICAL EVIDENCE FROM SURVEYOR 1.

K. V. Bdlow (Rostock, University, Rostock, East Germany).

IN: INTERPRETATION OF LUNAR PROBE DATA; AMERICAN ASTRONAUTICAL SOCIETY, SPECIALIST SYMPOSIUM, HUNTINGTON BEACH, CALIF., SEPTEMBER 17, 1966, PROCEEDINGS.

Edited by Jack Green.

Tarzana, Calif., American Astronautical Society (AAS Science and Technology Series. Volume 14), 1967, p. 163-165.

Study of seleno-geological evidence obtained from Surveyor 1 concerning a number of properties of the lunar surface which have long been only suspected. It is pointed out that on the moon there are no transport forces of terrestrial magnitude. As a result most the "weathering products" remain at the site of their origin. Surveyor 1 has confirmed this assumption as far as the thickness of the loose rock cover is concerned. The pictures also make it possible to see that the stone particles are frequently rounded, whereas they would have to have sharp edges if purely mechanical disintegration were involved. The Surveyor 1 pictures give evidence of volcanic genesis. M. F.

A67-40953

SOME GEOLOGICAL ASPECTS OF THE LUNAR CRUST - AN INTERPRETATION OF PHOTOGRAPHS TAKEN BY RANGER, SURVEYOR AND ORBITER PROBES.

S. Miyamoto (Kyoto, University, Institute of Astrophysics, Kwasan Observatory, Kyoto, Japan).

IN: INTERPRETATION OF LUNAR PROBE DATA; AMERICAN ASTRONAUTICAL SOCIETY, SPECIALIST SYMPOSIUM, HUNTINGTON BEACH, CALIF., SEPTEMBER 17, 1966, PROCEEDINGS.

Edited by Jack Green.

Tarzana, Calif., American Astronautical Society (AAS Science and Technology Series. Volume 14), 1967, p. 177-184.

Account of data on the lunar surface and crust obtained from photographs taken by the Ranger, Surveyor, and Orbiter probes. Data on craters with ring tectonics, the distribution of lunar events, lunar craters and terrestrial calderas, and the distribution of maria and "terra" are discussed. M. F.

A67-40954

A67-40954

LUNAR SURFACE CHARACTERISTICS.

P. Moore (Armagh Observatory, Armagh, Northern Ireland).
IN: INTERPRETATION OF LUNAR PROBE DATA; AMERICAN ASTRONAUTICAL SOCIETY, SPECIALIST SYMPOSIUM, HUNTINGTON BEACH, CALIF., SEPTEMBER 17, 1966, PROCEEDINGS. Edited by Jack Green.
Tarzana, Calif., American Astronautical Society (AAS Science and Technology Series. Volume 14), 1967, p. 185-188.

Analysis of the striking similarity between photographs of the Icelandic lava fields and photographs of the lunar surface obtained by Luna 9. It is pointed out that the various isolated rocks shown by Luna and Surveyor cannot be meteorites, which would have impacted explosively. The moon's surface is thought to be essentially volcanic. M. F.

A67-40998

VISCOUS FLOW OF CRATERS.

Ronald F. Scott (California Institute of Technology, Div. of Engineering and Applied Science, Pasadena, Calif.).
Icarus, vol. 7, Sept. 1967, p. 139-148. 7 refs.

The viscous flow equations of Haskell describing the very slow axially symmetric flow of a linearly viscous liquid initially subject to a crater-shaped surface disturbance have been solved numerically. The solution is presented in a curve showing the return of the center of the perturbation to the original surface level as a function of time. A discussion of the stability of this type of viscous flow is given, together with a stability criterion due to Tait. Application of the results to lunar craters is considered, and finally a description is given of some viscous flow model studies, which may be of value in the solution of more complex viscous flow problems of this type.

(Author)

A67-41003 *

THE STRUCTURE OF THE LUNAR SURFACE AS INDICATED BY THE GEOMETRY OF IMPACT CRATERS.

Evan Harris Walker (Miami, University, Coral Gables, Fla.; NASA, Electronics Research Center, Cambridge, Mass.).
Icarus, vol. 7, Sept. 1967, p. 183-187. 14 refs.
Grant No. NGR-10-007-011.

An analysis of laboratory hypervelocity impact cratering experiments shows that high values of the projectile to target density ratio result in craters having a high penetration to diameter ratio. As a result, iron or stony meteoroids impacting on either cohesive vesicular lava (rock froth) or solid rock produce extremely deep craters. High-velocity impact craters formed in granular surfaces result in shallow craters. The absence of deep craters in the Ranger photographs or in the Luna 9 photographs favors a granular structure for the lunar surface. (Author)

A67-41005

ABSOLUTE COORDINATES OF LUNAR FEATURES.

G. A. Mills (Manchester, University, Dept. of Astronomy, Manchester, England).
Icarus, vol. 7, Sept. 1967, p. 193-220. 14 refs.
Grant No. AF EOAR 64-49.

Derivation of absolute coordinates for a group of 910 lunar features by stereoscopic techniques based on the observation that a lunar feature changes its apparent position on the lunar surface with the libration. A large number of plates taken at widely different librations are used in order to reduce errors inherent in most coordinate systems produced heretofore. Tables of coordinates are given for lunar features and control points. V. Z.

A67-41007 *

STATISTICS OF IMPACT CRATER ACCUMULATION ON THE LUNAR SURFACE EXPOSED TO A DISTRIBUTION OF IMPACTING BODIES.

Evan Harris Walker (Miami, University, School of Environmental and Planetary Sciences, Coral Gables, Fla.; NASA, Electronics Research Center, Cambridge, Mass.).
Icarus, vol. 7, Sept. 1967, p. 233-242. 13 refs.
Grant No. NGR 10-007-011.

Statistical study of the distribution of impact craters on the lunar surface as a function of crater size and time of exposure to impacting bodies, showing that the initially valid time-dependent relation between the crater incidence and the impact exposure time becomes largely irrelevant as the crater incidence density approaches saturation with time. An equation is derived for the distribution of secondary craters produced during the formation of a primary crater. The equation is used to demonstrate that the secondaries do not contribute considerably to the "moonwide" statistics of craters larger than 100 m. Except for Mare Cognitum, the lunar highlands are found to be crater-saturated. An examination of Ranger-7 photographs is believed to indicate that the age of the maria is about 1.5×10^6 years. Remarks are made on the distribution of Martian craters. V. Z.

A67-41008

LIMITS OF LUNAR SOIL DENSITY.

John W. Salisbury and Joel E. M. Adler (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Bedford, Mass.).
Icarus, vol. 7, Sept. 1967, p. 243-250. 10 refs.

Discussion of recent laboratory evidence concerning the photometric properties of lunar surface materials. The highly underdense "fairy castle" model of the uppermost lunar surface is disputed in the light of this evidence and Surveyor 1 photographs. Laboratory tests of the density of rock powders in various size ranges sifted in ultrahigh vacuum indicate a probable upper density limit of about 1.5 gm/cm^3 for the bulk of the lunar surface material. The importance of grain shape in controlling density is demonstrated, and a value of about 1.0 gm/cm^3 is given as a likely lunar density to be used in calculating bearing strength, thermal conductivity, and the dielectric constant. V. Z.

A67-41012

LUNAR ORBITER PHOTOGRAPHS.

T. W. Rackham (Manchester, University, Dept. of Astronomy, Manchester, England).
Icarus, vol. 7, Sept. 1967, p. 263-267.

Note on photographs of the lunar surface taken by Lunar Orbiter 2. Photographs of Copernicus H and of the interior of the Copernicus peak cluster are described, noting their good quality. V. Z.

A67-41013

PHOTOMETRIC STUDIES OF TWO LUNAR DOMES.

A. S. Rifaat (Helwan Observatory, Cairo, Egypt; Manchester, University, Dept. of Astronomy, Manchester, England).
Icarus, vol. 7, Sept. 1967, p. 267-273.

Photometric representation of lunar domes 1 and 2 in Mare Tranquillitatis from photographs obtained by the Manchester Lunar Group at the Pic-du-Midi Observatory, by using photometric techniques suggested by van Diggelen in 1951. The procedure used is described, and photometric plots of the domes are given. The usefulness of photometry in interpreting earth-based lunar relief pictures is noted. V. Z.

A67-41370 *

THE DESIGN AND USE OF THE SURFACE SAMPLER ON THE LUNAR SPACECRAFT SURVEYOR III.

D. H. Le Croisette and C. E. Chandler (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
IN: INSTRUMENT SOCIETY OF AMERICA, ANNUAL CONFERENCE, 22ND, CHICAGO, ILL., SEPTEMBER 11-14, 1967, PROCEEDINGS. VOLUME 22. PART II - PHYSICAL AND MECHANICAL MEASUREMENT INSTRUMENTATION.
Pittsburgh, Instrument Society of America, 1967. 10 p.

Description of the design and operation of the Surveyor surface sampler. The structural features of the sampler are shown. The

surface sampler, as a part of the lunar soft-landing spacecraft Surveyor 3, succeeded in picking, digging, scraping, and transporting lunar surface material during the operations of the Surveyor 3 mission. Operation of the surface sampler was accomplished by command from earth. The operation was monitored through a slow-scan television camera aboard the spacecraft. The camera provided the photographic data used in assessing the effect of the operations of the surface sampler on the lunar surface. M.M.

A67-41510

SOLAR CELL ARRAY FOR LUNAR SURFACE OPERATIONS.
A. E. Mann (Textron Electronics, Inc., Spectrolab Div., Sylmar, Calif.).
IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, PHOTOVOLTAICS SPECIALISTS CONFERENCE, 6TH, COCOA BEACH, FLA., MARCH 28-30, 1967, CONFERENCE RECORD, VOLUME 2 - SPACECRAFT POWER SYSTEMS, SOLAR CELL MATHEMATICAL MODEL.
New York, Institute of Electrical and Electronics Engineers, Inc., 1967, p. 108-161.

General trade-offs of solar cell array concepts and solar cell devices are discussed in detail to determine their feasibility for power generation during lunar surface operations. Substantial system weight reduction is considered a positive advantage of using solar cell arrays. A further compensation would be the continuing power capability available after departure of the Ascent module, leading, after several missions, to a network of power stations for more advanced studies on the lunar surface. The use of solar cell arrays on the moon is considered imminent. (Author)

A67-41597

LURAIN SIMULATOR FOR EXTENDED METABOLIC STUDIES.
B. D. Newsom, R. L. Wolf, and E. J. Russ (General Dynamics Corp., Convair Div., San Diego, Calif.).
IN: AEROSPACE MEDICAL ASSOCIATION, 1967 ANNUAL SCIENTIFIC MEETING, WASHINGTON, D.C., APRIL 10-13, 1967, PREPRINTS OF SCIENTIFIC PROGRAM.
Washington, D.C., American Medical Association, 1967, p. 164, 165. Abridged.

Consideration of the requirements involved in an efficient determination of the oxygen consumption rate during ambulatory exploration of the lunar surface and a brief description of a lunar-terrain simulator designed for facilitating such estimates. Factors determining the rate of oxygen consumption are examined and problems involved in gravity and surface simulation are considered. A circular suspension track providing 1.6-g simulation at a 4-mph rate of travel is described. T.M.

A67-41657 *

THE USE OF SIMPLE PHYSIOLOGICAL MEASUREMENTS IN OBTAINING RELATIVE ENERGY EXPENDITURE AND WORKLOADS DURING A SIMULATED LUNAR SURFACE MISSION.
John E. Haaland (Honeywell, Inc., Aerospace and Defence Group, Systems and Research Div., Systems and Research Center, Minneapolis, Minn.).
IN: AEROSPACE MEDICAL ASSOCIATION, 1967 ANNUAL SCIENTIFIC MEETING, WASHINGTON, D.C., APRIL 10-13, 1967, PREPRINTS OF SCIENTIFIC PROGRAM.
Washington, D.C., American Medical Association, 1967, p. 309, 310. Abridged.
Contract No. NAS 8-20006.

Use of physiological measurements such as food and water intake, waste output, and the continuous telemetry of heart and respiratory rates to obtain information on the relative energy expenditure and task workload of calibrated personnel in a remote and hostile environment. The relationship of oxygen consumption and heart rate is graphed, and the mean heart-rate task profiles as a percent of maximum work are plotted. M.F.

A67-42034 *

ADHESION OF LUNAR SOIL SIMULATED BY ROCK COMMUNUTED IN VACUUM.

P. Blum, J. R. Roehrig, and M. J. Hordon (National Research Corp., Cambridge, Mass.).

IN: AMERICAN SOCIETY FOR TESTING AND MATERIALS, INSTITUTE OF ENVIRONMENTAL SCIENCES, AND AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, SPACE SIMULATION CONFERENCE, 2ND, PHILADELPHIA, PA., SEPTEMBER 11-13, 1967, TECHNICAL PAPERS.

Philadelphia, American Society for Testing and Materials, 1967, p. 63-68. 10 refs.

Contract No. NAS 1-5347.

An apparatus was constructed for reducing rock to powder in ultrahigh vacuum. The purpose was to simulate lunar soil with its attendant degree of particle surface cleanliness and thus to investigate its adhesive qualities. Basalt components were mutually abraded under a mean atmospheric pressure of 4×10^{-9} torr. The resulting powder, both free and compressed, adhered in forms having no air-ground counterparts. These included self-supporting flakes, angular-shaped aggregates, and accumulations on vertical rock grinding surfaces. The increased adhesion may account for some of the "rocks" in lunar photographs. (Author)

A67-42308

THE FEEL OF THE MOON.

Ronald F. Scott (California Institute of Technology, Pasadena, Calif.).

Scientific American, vol. 217, Nov. 1967, p. 34-43.

Discussion of the results of the Surveyor 5 scientific experiment, with particular reference to the results obtained with the aid of a surface sampler equipped with devices measuring the position of the sampler and the amount of force applied by the sampler to the lunar surface in its movements. Photographs and TV pictures of this and a similar experiment carried out by Surveyor 3 are given and discussed. It is seen that the lunar surface at the landing site resembles granular terrestrial soil. V.P.

A67-42986

GEOLOGIC RESULTS FROM THE LUNAR PRECURSOR PROBES.

John F. McCauley (U.S. Geological Survey, Flagstaff, Ariz.).

American Institute of Aeronautics and Astronautics, Annual Meeting and Technical Display, 4th, Anaheim, Calif., Oct. 23-27, 1967, Paper 67-862, 9 p. 25 refs.

Members, \$1.00; nonmembers, \$1.50.

Examination of some geological findings of lunar probes prior to the fall of 1967. United States and Soviet spacecraft have contributed in less than 3 years an immense wealth of new and exciting lunar data. Earlier telescopic investigations provided only a broad geologic framework against which to test hypotheses on surface-shaping processes. Rangers 7 and 8 showed convincingly that the moon is extensively cratered by impact to the 1-m scale; Ranger 9, however, showed many small craters that are of probable internal origin. In addition to small craters, Surveyors 1 and 3 revealed numerous angular blocks of coherent material quarried from shallow depth beneath a regolith of impact debris. The first Lunar Orbiter provided extensive photography of potential Apollo landing sites, the entire front-face, and most of the far side. In addition the Orientale Basin, the youngest of the large circular basins, was photographed, along with the "Marius Hills," a complicated volcanic area where igneous differentiation may have occurred. The Orbiter missions have also provided criteria for distinguishing large impact craters from large volcanic craters. The precursor probes have shown that the moon is geologically complex. Its detailed surface exploration during Apollo and subsequent programs will contribute greatly to our knowledge of planetary evolution. (Author)

A67-43012

UTILIZATION OF LUNAR CRATERS FOR LOW-FREQUENCY RADIO ASTRONOMY.

John M. Greiner (General Electric Co., Missile and Space Div., Philadelphia, Pa.).

American Institute of Aeronautics and Astronautics, Annual Meeting and Technical Display, 4th, Anaheim, Calif., Oct. 23-27, 1967, Paper 67-904, 13 p. 16 refs.

Members, \$1.00; nonmembers, \$1.50.

A detailed analysis has been made of the feasibility, advantages, and limitations associated with employing lunar craters as low-

A67-43070

frequency parabolic reflectors. Frequency, resolution, and location constraints governing the selection of suitable craters are determined from the environmental conditions and proposed mission goals which might influence a reflector operating on the lunar surface. From the statistical and geometric properties of actual crater elevation contours, 30 suitable parabolic craters 13.7 to 30.6 km in diameter have been identified. Their electromagnetic characteristics, estimated from the theory of a dielectric parabolic reflector, include a 49 to 309 kHz usable frequency range, effective apertures of 2.9 to 4.7 km, focal heights of 5.5 to 20.7 km, and subsurface homogeneity requirements at depths of 50 to 318 m. It is concluded that existing parabolic craters could provide low-frequency pencil-beam resolutions and effective apertures greatly exceeding those of terrestrial radio telescopes. The enormous focal heights, however, pose a major obstacle to crater utilization. (Author)

A67-43070

SOME RESULTS OF MEASUREMENTS OF THE TOTAL STOKES VECTOR FOR DETAILS OF THE LUNAR SURFACE.

Iu. N. Lipetskii and M. M. Pospergelis (Moskovskii Gosudarstvennyi Universitet, Astronomicheskii Institut, Moscow, USSR).

(*Astronomicheskii Zhurnal*, vol. 44, no. 2, 1967, p. 410-412.)

Soviet Astronomy, vol. 11, Sept.-Oct. 1967, p. 324-326. Translation.

[For abstract see issue 15, page 2552, Accession no. A67-29147]

A67-43073

REFLECTION COEFFICIENT FOR A PLANE-LAYERED LUNITE MEDIUM FOR DIFFERENT ANGLES OF INCIDENCE OF ELECTROMAGNETIC WAVES.

Iu. G. Matveev (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).

(*Astronomicheskii Zhurnal*, vol. 44, no. 2, 1967, p. 419-425.)

Soviet Astronomy, vol. 11, Sept.-Oct. 1967, p. 332-336. 7 refs. Translation.

[For abstract see issue 15, page 2552, Accession no. A67-29150]

AEROSPACE MEDICINE AND BIOLOGY ABSTRACTS

A67-81403

RECOGNITION OF LUNAR CRATERS.

James Wilde, Jerome Siegel, and James Williams (Kollsman Instr. Corp., Syosset, N. Y.).

Human Factors, vol. 9, Feb. 1967, p. 33-38. 7 refs.

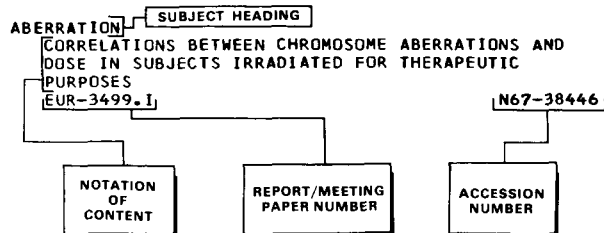
Recognition thresholds for lunar crater size were determined, analytically, for various look angles and magnifications, at an orbital altitude of 80 nautical miles. Elliptical image measurements for various sized craters were combined with some previous threshold recognition data for the ellipse. Elliptical image measurements consisted of the visual angle of the major axis, and elliptical form (the ratio of minor axis to major axis). A computer program was generated from which the visual angle and form measurements of anticipated elliptical crater images were computed for various combinations of crater size, look angle, and magnification. Previous data were then re-worked to obtain the visual angle and form measurements associated with the recognition threshold data for the ellipse. By graphically combining the visual angle and form data from both computations, 50% and 75% threshold recognition curves were generated, relating crater size, magnification and look angle. Implications of these data are discussed.

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LUNAR SURFACE STUDIES / a continuing bibliography with indexes

JUNE 1968

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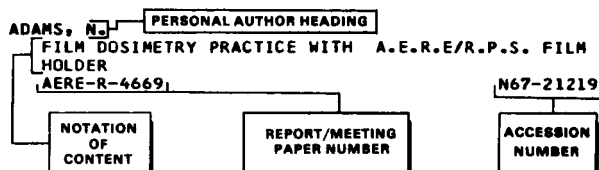
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